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UNIVERSITY OF ALBERTA
COLLEGE OF AGRICULTURE

Soil Survey of Milk River Sheet

BY

F. A. WYATT AND J. D. NEWTON
(*With Appendix by J. A. Allan*)
University of Alberta

W. E. BOWSER AND W. ODYNSKY
Dominion Department of Agriculture
Experimental Farms Service

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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.

This report describes the properties of the surface and subsoil of the various soil types, and gives the fertility invoice of the principal areas. It describes the topography, drainage, water supply, and alkali problems of the area. Methods of soil management and possible utilization of the area are discussed. It also contains a brief discussion of the climate and agricultural development of the area, together with the important farm crops and transportation facilities.

The soil map is an important part of this report. It is made on the scale of three miles to the inch, and shows not only the different soil types but also important features such as topography, railroads, streams and towns. The soil map serves as a basis by which the better land can be distinguished from the poorer land as well as indicating the best method of utilization. Two other maps accompany this report: one shows the distribution of the cultivated, abandoned and virgin lands in the area, and the other shows the possible utilization of the area.

The area covered by this report, namely, the Milk River sheet, lies in the semi-arid portion of Alberta, and rainfall is a limiting factor in crop production over most of this sheet. This low annual rainfall over a long period of time has limited the native vegetative growth, resulting in a soil type with a low initial fertility, particularly of the element nitrogen. At the present time on this sheet there are about 50,000 acres of land, once cultivated, that are now abandoned. This land lies principally in the east half of the sheet. In general, this abandoned land, besides being dry, is an inferior soil type. Farmers from this land have relocated in other parts of the sheet or have moved to other sections of the country. This readjustment is possibly not yet completed, for some marginal or submarginal land is still being cultivated. (The development of local irrigation projects may also cause some rearrangement of the settlement.) A soil survey conducted prior to settlement might have prevented the spending of much money and many years of relatively futile labor in attempting to build up homes on submarginal land. However, a soil report is not without value today. It can delineate what areas might still be cultivated and what areas should be used permanently as pasture. This is a definite guide for any future relocation of settlers or settlement due to proposed water development. Any transferring of settlers from one community to another cannot be done without great expense, both to the individual and to the community, first in the actual cost of moving, secondly in the loss of investment in the original home, and thirdly in the loss in production while these settlers are being established in their new homes. The soil survey, in delineating those areas that are agriculturally non-arable over a long term of years, should aid in preventing the cultivation of such areas during favorable climatic periods, particularly in the time when the need for greater production may tend to bring these lands into production.

The soils of the province are still our greatest natural resource. However, observation has shown that soil deterioration is taking place. This is manifest in severe wind erosion, the spread of alkali in some irrigation districts, and in a general drop in fertility over a long period of years. Such a deterioration of productive land is a serious condition from both the individual and from the national viewpoint. Soil types vary in their response to rainfall, to irrigation water, and to farm management. The soil survey, by mapping the soils of the area, determines the boundaries of the various soil types and has recorded the chemical and physical properties of each type. Such information is necessary if each land parcel is to be utilized to its best advantage and to do this means to maintain the most profitable production without inducing any unnecessary deterioration.

An inventory of the soil's resources is necessary before the adequate size of a self-sustaining farm unit can be calculated, and hence the maximum number of such units that an area will economically carry over a long period of years.

The results of crop, fertilizer and cultural method experiments obtained at the larger government experimental stations in our province do not necessarily apply to all parts of the province. Similarly, results from local illustration stations apply particularly to the soil types similar to the one at the station. When planning experiments in various parts of the province the soil maps should prove very valuable, since they would show where 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 results on their land similar to those obtained on the experimental plots, since the soil maps would tell him whether the soils were or were not alike. Similarly, the soil reports tend to place the information of one farmer at the disposal of the other farmer.

The need for a planned agriculture that will stabilize the farming industry of our province is becoming more and more apparent. The spectacle of soil deterioration, uneconomic use of land units, and deserted homes, as well as such things as tax delinquency and mounting relief costs, cannot continue indefinitely. A survey of the soil resources is a first step in obtaining the goal of any planned land use.

Soil Survey of Milk River Sheet

BY

F. A. WYATT AND J. D. NEWTON
(With Appendix by J. A. Allan)
University of Alberta

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Dominion Department of Agriculture
Experimental Farms Service

DESCRIPTION OF THE AREA

The Milk River sheet, located in the southeast corner of Alberta, is an area 90 miles east and west by 48 miles north and south. More exactly, it consists of townships 1 to 8 inclusive that are within ranges 1 to 15 inclusive, west of the fourth meridian.

The southern boundary lies along the international boundary and the eastern edge along the Alberta-Saskatchewan boundary. The area extends on the east from a point about 13 miles east of Elkwater lake to the southeast corner of Alberta , and on the west from a point about 8 miles southeast of Taber to a point two miles west of Coutts.

The soil map for the area described above represents 120 townships or 2,765,000 acres. This area was covered by the Alberta Soil Survey, P.F.R.A., during portions of the summers of 1935, 1938 and 1939.

In general this area is of undulating to gently rolling topography cut by deep eroded coulees. There are, however, two major elevations. The Sweet Grass hills, one prominent landmark, lie across the international boundary in Montana. These hills, pushed up by a subterranean force, reach an elevation of over 5,000 feet. Their foothills are found in this sheet, particularly in tp. 1, ranges 11, 12 and 13. The other elevation is the Cypress hills in the northeast corner of the sheet. Although called hills, the area is in reality the remnant of a pre-glacial plain. It consists of a level plateau and a steep, eroded escarpment leading to the lower post-glacial surrounding plain. This level plateau, sloping slightly to the east and south, has its

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western end in tp. 8, range 3, and its eastern end in Saskatchewan. It varies from 2 to 5 miles in width. The drop from this plateau to the surrounding plain, as stated, is cut by numerous eroded coulees and gives the appearance of a very hilly country. Low morainal ridges are found north of the village of Etzikom and south of Etzikom coulee. Fortymile, Chin, Etzikom and Verdigris coulees, deep wide channels cut through a relatively level plain, are prominent topographic features in the west half of the sheet.

Excluding the two major elevations described above, there is a slight general drop in elevation from the west to the east and north. Coutts in the southwest corner of the sheet has an elevation of 3,464 feet, Conrad in tp. 6, range 15, an elevation of 3,078, and the northwest corner of the sheet an elevation of 2,718 feet. The elevation of the northwest corner of tp. 8, range 7 of 2,742 feet indicates that there is very little elevation difference for fifty miles east of the northwest corner. From tp. 8, range 7, east, there is a rapid rise in elevation to the top of Cypress hills. The elevation of the southeast corner of tp. 1, range 1, is 2,807 feet, that is almost 100 feet higher than the northwest corner of the sheet. Conrad, as stated, has an elevation of 3,078 feet. Foremost, 25 miles to the east, has an elevation of 2,919 feet and Manyberries, about 30 miles east of Foremost, an elevation of about 3,000 feet. The following elevations along the second base line give the general elevation trend through the centre of the sheet (the elevations are at the northeast corner of each designated township): tp. 4, range 16—3,126 feet; tp. 4, range 13—3,066 feet; tp. 4, range 10—3,007 feet; tp. 4, range 7—2,844 feet; tp. 4, range 5—3,195 feet; tp. 4, range 3—3,570 feet; tp. 4, range 2—3,372 feet; and tp. 4, range 1—3,343 feet. Pendant d'Oreille in tp. 3, range 7, Comrey in tp. 2, range 6, and the north side of tp. 2, range 1, are all close to the 3,000 foot contour. There is a fairly rapid climb in elevation to the north and east, that is, up to the Cypress plateau, from the last four named points. The top of the Cypress plateau in tp. 8, range 3, reaches an elevation of 4,800 feet; this is the high point of the sheet. Elkwater lake in tp. 8, range 3, at the base of the north escarpment, has an elevation of approximately 4,200 feet. It is interesting to note here that Waterton Lakes in the Rocky Mountains in the southwest corner of Alberta has an elevation of 4,202 feet. South of Milk River there is a gradual rise in elevation to the Sweet Grass hills across the international boundary. In tp. 1, range 12, an elevation of 4,200 feet is reached at the boundary just north of the west butte. The low point of the sheet is possibly the point in tp. 8, range 8, where Seven Persons coulee enters the Medicine Hat sheet, namely, an elevation of slightly over 2,500 feet. The point where Milk River leaves the sheet in tp. 1, range 4, is possibly a little higher than the figure of 2,500 feet given above for Seven Persons coulee. Pakowki Lake, at present the centre of an inland drainage system, has an elevation of 2,807 feet.

Three river systems drain the area, namely, the Milk River system which drains into the Mississippi, the Saskatchewan river system which drains into the Nelson, and an internal system leading to Pakowki lake. The south side of the sheet and the east side, south of the Cypress hills plateau, is drained by the Milk River drainage system. Milk River enters the sheet in tp. 2, range 15, just east of Milk River town, flows almost due east to Comrey in tp. 2, range 6, and then turns southeast to leave the sheet in tp. 1, range 4. Although this river's flow varies considerably with the season it is the only large water course on the sheet that has a continuous summer flow. This river has a large wide valley over its entire length (see Plate 7, Fig. 3), the portion east of Pentant d'Oreille coulee (in tp. 3, range 8) is typical bad land topography and cuts into the plain to a depth of over 300 feet. Red coulee in tp. 1, range 15, Police creek in tp. 1, range 13, Deer creek in tp. 1, range 12, Deadhorse creek in tp. 1 and 2, range 11, Halfbreed creek in tp. 1 and 2, range 10, Bear Gulch creek in tp. 1 and 2, range 9, and Police coulee in tp. 1 and 2, range 8, are intermittent streams that drain from the Sweet Grass hills to Milk river. Verdigris coulee enters the sheet in tp. 3, range 15, and joins the Milk river in tp. 2, range 14. Pentant d'Oreille coulee in tp. 3, range 8, is an old drainage connection between Milk river and Pakowki lake. This coulee at the northeast corner of tp. 3, range 8, where it enters Pakowki lake, according to William and Dyer's memoirs No. 163, is 36 feet lower than the present bed of Milk river. In the southeast corner of the sheet Lost river, Sage creek, Lodge creek, North Fork and Battle creek are some of the larger coulees that drain south and east to the Milk river drainage system. Lodge and North Fork creeks have their headwaters along the south side of Cypress hills.

Chin and Fortymile coulees which join in tp. 7, range 9, to form Seven Persons coulee, drain the north side of the sheet to the South Saskatchewan river. Peigan creek, that has its headwaters in tp. 8, range 4, joins Seven Persons coulee in tp. 8, range 8. Bullshead and Ross creeks drain north from the Cypress hills.

Between the Milk and South Saskatchewan systems lies the internal drainage system ending in Pakowki lake. Etzikom coulee enters the sheet from the west between tp. 5 and 6, range 15, and empties into Pakowki lake in tp. 5, range 9.

Coal, Canal, Ketchum, Manyberries creeks and a creek just south of Orion drain the west side of the Cypress elevation into Pakowki lake. These are all seasonal streams.

Verdigris, Etzikom and Chin coulees must at one time have carried large volumes of water and have drained from the large Lethbridge laking basin. Canal creek and Lost river, although draining in opposite directions, lie in the same erosion coulee; Bullshead and Medicine Lodge creeks also lie in a continuous valley.

Numerous springs were found around the edge of the Cypress hills plateau. They are particularly numerous along the south escarpment and are a valuable source of stock water. A few springs were also found south of Milk river below the Sweet Grass hills.

Flowing (artesian) wells can be had in many districts by drilling between 500 and 1,000 feet. There is a number of these wells in the sheet particularly in the northwest quarter (see Plate 2, Fig. 3).

Elkwater lake in tp. 8, range 3, is the largest natural lake in the sheet. At the present time, 1939, it is over a mile long and about a mile wide at the widest point. The lake, in places, is quite deep. It is fed by spring runoff and by springs from the Cypress hills. Kings lake, originally called Crow Indian lake, in tp. 5, range 13, is a long narrow lake in the bed of Etzikom coulee. It is quite shallow. It is fed by the spring runoff and by some irrigation spill water. Verdigris lake in tp. 3, range 15, was dry in 1938. Green lake in tp. 6, range 1, had some water in the south half in the summer of 1939. This lake is fed by a small spring fed stream. The small lake in tp. 1, range 4, was full of water in 1939. Milk and Sage lakes in tp. 1, range 2, and the lake in tp. 8, range 5, were dry in 1939.

Pakowki lake was completely dry in 1939 and has been dry for six or seven years. However, at least twice since 1910, namely, during the 1914-16 and 1927-30 wet periods, there was considerable water in this lake. It is, then, in the nature of an intermittent lake. The fact that a considerable amount of flood irrigation is practised along the east side of the lake reduces the volume of spring runoff that reaches the lake bed proper.

Some stock watering dams have been constructed in the area. Without these, stock in some places would have unreasonable distances to go for water. There is a very great number of sites still available for such dams as well as some sites for larger dams to supply irrigation water. At present a fairly large area on the east side of Pakowki lake is flood irrigated by using the spring runoff. No storage dams have been built for this scheme. A few small irrigation systems, similar to the one at the Dominion Range station in tp. 2, range 4, are in operation.

The area covered by this report lies principally in the brown soil zone of Alberta, that is in the treeless semi-arid plain of southeastern Alberta. Two small areas of darker soil, however, have been mapped in the area. One of these is associated with the Sweet Grass hills elevation, and includes portions of tp. 1 in ranges 9, 10, 11, 12 and 13. The other area is in the Cypress hills. The line dividing the brown from the dark brown soil in the Cypress hills area runs from tp. 8, range 6, to the northeast corner of tp. 5, range 4, and then east by northeast to Green lake. Going east and north from this line the soil gradually gets darker. On the map a fairly large area of shallow black soil is mapped and at the highest point, namely in tp. 8, range 3, a small area of normal black soil is outlined. On the steeply wooded escarpment, particularly on the north slope, some of the soils show definite evidence of podsolization. It is interesting to note that if one were to travel from the northeast corner of tp. 5, range 4, to the top of the plateau in tp. 8, range 3, a distance of about 14 miles, and an increase in elevation of about 1,000 feet, he would pass through a sequence of soil color zones similar to what he would traverse in travelling from Manyberries to Edmonton, a distance of over 300 miles.

The soil in the west half of the sheet has, in the main, developed in sorted and unsorted glacial drift and is from medium to medium heavy textured. Hudson Bay erratics are quite numerous and, although at no place does this drift appear to be very deep, there is a mantle over most of the area. North of Chin coulee there has been considerable sorting of this material. Low moraines are found north of the village of Etzikom and south of Etzikom coulee. Cypress hills plateau, it is believed, was not covered by the continental ice sheet and the soil profile here has formed on an unglaciated remnant of the Tertiary plain. The remainder of the area east of Pakowki lake has been glaciated but has in many places lost, by erosion, the till covering so that the soil profile is formed from the weathered parent rock and the erratics are, for the most part found on the surface. A fuller description of the soils of this sheet is found in the section on Soils; and the appendix by J. A. Allan describes the geology of the area.

A branch line of the Canadian Pacific Railway from Stirling, Alberta, to Shaunavon, Saskatchewan, traverses the sheet. It enters on the west side in township 6, range 15, and leaves on the east side in tp. 3, range 1. Foremost in tp. 6, range 11, is the largest town on this railway. It had a population of 290. Conrad, Skiff and Legend are railway stations west of Foremost. East of Foremost are the villages of Nemiscam, population 78, Etzikom, population 74, Orion, population 68, and Manyberries, population 118. Maryberries in tp. 5, range 6, is the farthest east trading centre on this railway. Craigower, Bain and Jaydot are railway sidings between Manyberries and the Saskatchewan boundary. The Lethbridge-Coutts railway cuts the extreme southwest corner of the sheet. Coutts, on the international border, had a population of 540. It should be noted here that the above population figures are taken from the 1931 census returns. Although some of these towns have had a larger population at one time, there has been little change since 1931; the principal exception to this is the town of Coutts which now has a population of about 250. Post office and trading post facilities are found in many of the districts that are some distance from the railway towns. Of these the following might be mentioned: Aden in tp. 1, range 10, Comrey in tp. 2, range 6, Lucky Strike in tp. 3, range 12, Pentant d'Oreille in tp. 3, range 7; Ranchville in tp. 7, range 5; and Thelma in tp. 7, range 2. Elkwater in tp. 8, range 3, caters to the holiday traffic to Elkwater lake. The railway through Lethbridge, Medicine Hat and Swift Current runs from 7 to 20 miles north of the north boundary of the Milk River sheet. It is therefore seen that railway facilities are somewhat limited and some portions of the sheet are 30 to 40 miles from these facilities. However, most of the cultivated land is within 20 miles of a railroad, that is, most of the outlying districts are ranch areas. The farming districts of Thelma, Comrey and Aden are between 20 and 30 miles from elevator facilities.

In general the area is fairly well supplied with dry weather dirt roads in the better settled areas. However, excepting the Lethbridge-Coutts highway that cuts the southwest corner of the sheet, there are no all weather roads in the area, and during wet weather traffic across the sheet is extremely difficult. The main travelled roads as well as the river and coulee crossings are shown on the soil map that accompanies this report. Milk River is crossed by three bridges. A graded road follows the railway as far east as Manyberries. Here it branches, one grade going north to Medicine Hat and one going southeast to the international boundary via Wildhorse. Two trails lead from Manyberries to the Cypress Hills and a graded road leads from Medicine Hat into the Cypress hills via Elkwater lake. There are Customs houses at Coutts, Aden and Wildhorse.

The bulk of the cultivated land on the sheet lies west of range 8 (see cultivation map, plate 5). There are also some fairly large cultivated areas north of Manyberries and Orion, in the flat east of Pakowki lake, in the Comrey district, and in the Thelma district. The bulk of the abandoned land lies east of range 9, particularly in the Manyberries and Pendant d'Oreille districts. There is also a fairly large acreage of abandoned land south of Lucky Strike and west of Aden. Dominion census returns show that the greater part of the abandonment took place between 1920 and 1925 and that since that time there has been, excepting for a few small areas, a slow rise in total cultivated acres. The area east and south of Manyberries is principally range land. The soil, climate, and topography have all acted as deterrent factors in preventing the cultivation of this area.

In the northeast corner of the sheet is the Cypress Hills Forest reserve. Lodgepole pine, white spruce and black poplar are the dominant trees in this reserve. These trees are a valuable source of wood and building materials for the farmers of this sheet. This forest growth is confined mainly to the deep ravines, the north escarpment and to the plateau above the 4,500 foot level. Coal is found in many places across the sheet and in some places is readily accessible. Among the places that are fairly actively mined might be mentioned tp. 2, range 15, tp. 3, range 11, along Fortymile coulee, and along the south bank of Elkwater lake. There is a natural gas field east of Foremost and some of the artesian wells give off some gas flow. There has been considerable oil drilling activity in this sheet, the largest individual field being the one south of Skiff.

Elkwater lake in the Cypress hills is a local summer resort. Located at the base of the heavily wooded north escarpment, it has a very pretty setting. Swimming, fishing and boating can be indulged in at the lake. Since here is the only large body of water and practically the only tree growth for many miles around, it is a welcome resort for those people who live on the surrounding semi-arid plains. It is, however, unfortunate that due to the higher rainfall in the hills, the roads are often very difficult to travel. Kings lake in tp. 5, range 13, harbours during some years a considerable number of ducks and is a popular local shooting ground. It is practically the only one in the area. Writing-on-Stone, located along Milk river in tp. 1, range 13, is of considerable historical interest and is worthy of preservation. The Indian character writing is in the Milk River sandstone. However, normal geologic erosion plus the addition of many recent "characters" are rapidly obliterating the Indian writing. An antelope reserve is located in tp. 7, range 9 and 10, north of Nemiscam. Antelope roam over the entire area excepting on top of the Cypress hills. There are a few deer in Cypress hills.

The area south and east of Manyberries, although difficultly accessible to motor traffic, is of extreme scientific interest. Species of flora and fauna are found here that are found nowhere else in Alberta. The Yucca plant and the horned toad are two that might be mentioned.

AGRICULTURE

Cypress hills, the most prominent landmark in southeastern Alberta, received mention in much of the early history of the western plains. This area was a favourite hunting ground of the Assiniboine Indians and was early visited by traders, trappers and the infamous rum-runners. So great was the need of maintaining law and order in these hills that between 1879 and 1882 the R.N.W.M.P. post at Fort Walsh (located in tp. 7, range 29, W. of 3rd) was made police headquarters with a large detachment. On the banks of Battle creek (in tp. 8, range 1, W. of 4th) stands a monument to Constable Graburn who was killed in 1879 when on patrol.

Captain Palliser visited the Milk River area while preparing a report on the western prairies for the British Parliament. On July 28, 1859, he wrote in his diary: "The Cypress mountain is indeed a great contrast to the level country through which we have been travelling. . . . The soil is rich and the water abundant. These hills are a perfect oasis in the desert . . . and are separated from the Rocky mountains by a wide tract of arid country." It is of interest to note here that in the early "eighties" a sawmill was in operation in the Cypress hills just southwest of Elkwater lake. In 1884 fire burned a large quantity of the timber on these hills. The stumps left from this lumbering business indicate that the trees at that time were larger than any found at present.

The first agriculture practised in this area, as in most of southern Alberta, was ranching. It is stated that in 1878 two ranchers moved cattle from Macleod to the Medicine Hat district, that in 1879 an irrigation ditch was constructed to flood hay lands in the Cypress hills, and that at the time of Constable Graburn's death there were some "old" settlers in the district. The Cypress Cattle Company was formed about 1888 and by 1892 the Bar-N-Bar ranch was operating south of Manyberries on the Pakowki flats. It is also reported that one, King, in the early eighties settled along the edge of the lake now known as King's lake. The ranching industry in this area continued to grow. At about the turn of the century there was a large influx of cattle to the area just north of the international border, the over-stocked range lands in Montana being the immediate reason. At the time some sheep ranches were established on the west side of the sheet. Although the ranchers were soon hemmed in by settlers and often forced to release their holdings to the ever encroaching plow, there still remain in the Milk River sheet large ranch holdings. At the present time (1939) there are still approximately two million acres of uncultivated land in this sheet, most of which is being used as range for the stock of the rancher, the rancher farmer, and the farmer.

In 1890 a fairly large number of farmers located between Medicine Hat and Bullshead, although it is reported that many left the next year to find more humid parts. However, settlement continued, radiating out from the Medicine Hat-Lethbridge railway built in 1895. The Alberta crop returns for 1905 indicate that this area did not have over 5,000 acres of cultivated land at that time. Most of this acreage was in wheat. The Manyberries to Foremost area was thrown open for homestead entry about 1909. This was the signal for a big influx of settlers. The branch railway line from Stirling was completed as far as Manyberries in 1917 and this was linked with the Govenlock, Saskatchewan, branch in 1923. The town of Manyberries in 1918, when it was at the end of steel, had a population of over 400 people.

There has been considerable abandonment in this area. This movement of settlers out of the area began about 1912 and reached a peak in 1921. Since that time, however, considerable new land has been broken and the holdings of many of the farmers have increased in size. In 1939 this survey estimated that there were about 50,000 acres of abandoned land, once cultivated, on the Milk River sheet.

There are no large irrigation projects in this area. The largest project is the flood irrigation practised in the Orion and Pakowki flats. By means of dykes the spring flood waters from Manyberries, Orion and Ketchum creeks are utilized. There is, therefore, just one flooding in the scheme, namely, the spring flood. On the flats immediately south of Orion cultivated grasses and grains are grown. The water from Manyberries creek is used to flood the native grass, now containing much volunteer sweet clover, for hay. This scheme was started by the ranchers, Huckvale and Hooper in the 'nineties. A small project is in operation on Deer Creek. One in this neighborhood was reported to have produced good watermelons in '99. A small pumping scheme is operating in tp. 2, range 7, and the Dominion Range station irrigates a parcel of land adjacent to the building site from a coulee dam. Other coulee dam projects are in operation and the possibility for greater development in this respect is receiving much needed attention.

TABLE I.—CROPPED ACREAGE IN THE MILK RIVER SHEET

	In Crop	Cultivated acres
1920	292,000	400,000
1925	192,000	300,000
1930	294,000	525,000
1935	311,000	600,000
1939	350,000	615,000

The data in Table I, for all but 1939, were obtained from the Dominion Government census returns by municipal units. Since some of these units fall only partially within the surveyed area, and since no acreages were obtained for hay crops (however, the total in hay and other specialized crops in this area is small), the figures given in this table must be considered as estimations. The total cultivated acres is computed by assuming that in 1920 about 1 acre out of three cultivated was fallow and in 1935 nearly 1 acre in two was fallow. The 1939 figure is computed from estimations made by this survey during the summer of 1939 (see cultivation map, plate 5).

From Table I it is seen that there was a big drop in cropped acres between 1920 and 1925 due, as stated earlier, to the large abandonment about 1921. The figures for 1935 and 1939 are, however, higher than the 1920 figure. Although this is true for the sheet as a whole, it does not apply to all districts. Municipal unit 32, comprised of tps. 4, 5 and 6 in ranges 4, 5 and 6, dropped from 17,000 cropped acres in 1920 to 8,000 acres in 1925 and had only recovered to 11,000 acres in 1935. Municipal unit 3, comprised of tps. 1, 2 and 3 in ranges 7, 8 and 9, presents a somewhat similar picture. However, municipal unit 5, comprised of tps. 1, 2 and 3 in ranges 13, 14 and 15, dropped from 36,000 acres in 1920 to 30,000 acres in 1925 but had 49,000 acres in 1935. In this connection the Cypress hills showed no decrease in 1925. The estimated cropped acreage in 1920 was 5,000 acres, in 1925 was 6,000 acres, and in 1935 was 7,000 acres.

Of this total cropped acreage about 90% was in wheat and most of the remainder in oats. Barley and rye form very small percentages of the total. That is, wheat is the principal cultivated crop in this sheet, almost to the exclusion of all other crops. Crop yield data for this sheet give at least one reason for this. The yields for oats, barley and rye are very low and have not given adequate returns in comparison to wheat. Part of the reason for the low yield of coarse grains may be the fact that these crops, in general, are not planted on land as well prepared as for the wheat crop.

The cultivation map (plate 5) shows that there are large blocks of land in this sheet still uncultivated. The area south and east of Manyberries and the area south of Milk River east of Deadhorse coulee, the area adjacent to Eagle Butte, and the area adjacent to King's lake, are among those larger blocks still remaining as range land. During the period 1926 to 1936 there has been an annual average of about 5,000 head of horses and 18,000 head of cattle marketed from census division I, the boundaries of which go north to the South Saskatchewan at Medicine Hat and west as far as Warner. It is estimated that about three-quarters of the above totals came from the Milk River sheet.

It is practically impossible to calculate specifically from the data available the average wheat yield for the area over the past twenty years. However, using station, municipal unit and census division yields, it is estimated that the average yield over the last twenty years has been about 11 bushels per seeded acre. The east side of the sheet is lower than this and the west half higher. Nor does this figure predict the future performance of the area. It is suggested that the average yield may rise due to at least two factors: one is the improved methods in farming technique in the dry area and the other is the gradual withdrawal from cultivation of submarginal lands. That is, provided adequate measures are taken to conserve the fertility. By way of comparison, the Rainy Hills sheet has been calculated to have an average of about 10 bushels per acre, the Lethbridge sheet about 16 bushels and the Edmonton district about 23 bushels. The average for the province is approximately 17 bushels per acre. The figure of 11 bushels per acre, as with the other figures quoted, takes in all soil types. Some of the better soil types in this area have certainly exceeded this average and individual farmers have far exceeded it. One farmer east of Warner on the brown soil has averaged 25 bushels per seeded acre on fallow over the last 25 year period and one farmer in the Nemiscam district has averaged 20 bushels per seeded acre over the last 20 year period.

The figure of 11 bushels per acre represents slightly less than 1 bushel of wheat per inch of rainfall. The individual records given above represent nearer two bushels per inch of rainfall. In the Edmonton district 1 inch of rainfall has produced about 1.3 bushels of wheat per acre. However, the fluctuation in any area between the wet and dry years is very great. How best to utilize the soil and moisture resources of this area still remains a major problem. Certain general suggestions are made in the section on farm practice. However, it can be stated that it is believed that certain sections of this area can best grow wheat; other areas are definitely range land. The allocation of the farm, ranch, and local irrigation lands of any area is worthy of considerable planning to determine how best to maintain a stable population on a self-sustaining basis, and possibly nowhere in the province is the problem more pertinent than in the Milk River sheet.

CLIMATE

The climate of the Milk River sheet is fairly 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 winter weather. Although lying a considerable distance from the Rocky Mountains, this sheet is influenced by the chinook winds. These winds may melt the snow and permit of some winter grazing, but they may also cause damage to the growing crops during the summer months. This can be very detrimental, especially during prolonged dry spells. Wind velocity records for the years 1932 to 1937 show that at Lethbridge the average annual wind mileage was 80,000 miles and at Medicine Hat 75,000 miles. During the same period Lacombe in central Alberta recorded less than 40,000 miles per year. During the years 1936 to 1939 the Manyberries Range Station (located in tp. 2, range 4, along the south slope from the Cypress hills) recorded an annual total mileage of 100,000 miles. During the year 1936 and 1937 the annual recorded mileage at Lethbridge was 77,000 miles, at Medicine Hat 72,000 miles, and at Manyberries 104,000 miles. During 1936 to 1939 at Manyberries there have been from 25 to 30 individual gales annually, totalling about 175 hours of wind over 31 miles per hour. The prevailing direction of these gales is from the northwest. It is thought that the chinook winds gradually lose velocity from west to east, that is, they are less intense on the Milk River sheet than on the Lethbridge sheet to the west.

The climate of this sheet is characterized by a relatively high amount of sunshine. A fourteen-year period at Medicine Hat gave an average of 2,354 hours of sunshine per year and a ten-year period at the Manyberries Range station gave an average of 2,305 hours annually; this is approximately an average of six and one-half hours sunshine for every day in the year.

All the meteorological data given in this report are compiled from the Dominion meteorological records. There are no long term records from the Milk River sheet, but both Lethbridge and Medicine Hat have complete records for a relatively long period of years. There are, however, a few shorter records from stations on or near the sheet and from these it has been possible to compile average precipitation records for the summer months (April to August inclusive). Records from nine such stations, reporting from eight to eighteen years, are reported in Table III. The records were more complete for the summer months than for the remainder of the year so that by using the April to August period a longer term average could be used. However, data from nearby stations were frequently supplied for months that were not reported. Records from the following stations were reported: Grassy Lake, Seven Persons, Foremost, Glassford, Groton, Coutts and Milk River, Manyberries range station, Govenlock (Saskatchewan), and stations on the Cypress hills.

Table II gives the monthly rainfall distribution at Medicine Hat and at Lethbridge. The year is divided into three parts, namely the previous fall, winter and the growing season.

TABLE II.—SEASONAL DISTRIBUTION FOR LETHBRIDGE AND MEDICINE HAT—PRECIPITATION IN INCHES.

	Lethbridge, 1902-37			Medicine Hat, 1885-1937			
	Average monthly precip-itation	Greatest amount in one month	Total amount in dryest year, 1918	Average monthly precip-itation 1885-1914	Average monthly precip-itation 1915-37	Greatest amount in one month	Total amount in dryest year, 1886
August	1.62	4.70	1.23	1.51	1.27	5.80	0.11
September	1.71	4.86	1.07	0.92	1.29	3.24	0.19
October	0.95	2.44	0.24	0.62	1.68	3.48	0.79
Previous fall	4.28			3.05	3.24		
November	0.72	2.88	0.43	0.72	.56	3.11	0.51
December	0.70	2.27	0.46	0.53	.86	2.94	0.28
January	0.65	1.76	0.46	0.61	.66	2.10	0.00
February	0.62	1.39	0.76	0.61	.44	1.51	0.00
March	0.86	2.30	0.66	0.61	.59	1.65	0.32
Winter	3.55			3.08	3.11		
April	1.10	4.37	0.13	0.61	.99	2.66	0.80
May	2.32	11.27	0.58	1.75	1.45	6.29	1.41
June	2.72	7.01	0.76	2.57	2.20	5.62	1.53
July	1.68	5.95	0.85	1.73	1.58	5.43	0.78
Growing season	7.82			6.66	6.22		
Total	15.66			12.79	12.57		6.72

This is done because the previous fall plus growing season moisture seems to be most closely related to crop yield. The figures for Lethbridge represent a 36-year average, 1902 to 1937, and the figures for Medicine Hat a 53-year average, 1885 to 1937. The average annual precipitation for Lethbridge is 15.66 inches, with 12.10 inches, that is 77%, falling during the growing season and previous fall. Medicine Hat has received an average annual precipitation of 12.70 inches with 9.60 inches, that is 76%, falling during the growing season and previous fall. It is seen that the Medicine Hat average for the period 1885 to 1914 is very close to the average for the period 1915 to 1937. During the period 1919 to 1937 Seven Persons received an annual precipitation of 13.70 inches. The figures for the above three stations indicate a general decrease in rainfall between Lethbridge and Medicine Hat.

As stated above, both Lethbridge and Medicine Hat receive over 75% of the total precipitation during the most effective period. This, fortunately, is typical of most of Alberta's rainfall distribution. If between nine and ten inches of rainfall during the growing season and previous fall be considered the border between those years that are considered drought years and those that are not, then at Lethbridge during the 22-year period 1916 to 1937, six years have been drought years and 1 year has been a border line year; that is, a little less than one year in three have been drought years. At Medicine Hat during the same period ten years have been drought years and four have been border line years; that is, about one-half of the years have been drought years. The above figures indicate how relatively closer to the drought border line is Medicine Hat in the centre of the brown soil zone than is Lethbridge which is located just west of the line between the brown and dark brown color zones, that is just in the dark brown color zone.

Table III gives the average April to August rainfall for the nine stations enumerated above. For purposes of comparison the Lethbridge and Medicine Hat averages for the same years as those used for the individual stations are given. The figure for Grassy lake would indicate that the rainfall at that station is lower than at either Medicine Hat or Seven Persons, farther east. Since this figure is only an average of eight seasons, it is questionable how much significance can be placed in it. However, during that period the Medicine Hat April to August rainfall was greater than at Grassy Lake in seven out of the eight years. Brooks, Alberta, has a slightly lower rainfall than Medicine Hat, namely 11.45 inches for the period 1916 to 1935.

Averages in Table III indicate that Foremost, Groton and Glassford each receive about the same amount of rainfall, with Foremost slightly higher than the other two. These three stations receive an annual rainfall possibly between 14.00 and 14.25 inches. In general the soils adjacent to and west of these three stations are slightly darker in color than the brown soils east of these stations; the darker color is due to a higher soil moisture condition. Records from Manyberries and Govenlock indicate that the rainfall in the extreme southeast corner of the sheet is slightly lower than the rainfall at Medicine Hat; the average annual precipitation is possibly slightly lower than 12.00 inches. Havre, Montana, located about 40 miles southeast of the southeast corner of the sheet, had an average annual precipitation of 13.67 inches for a 48-year period.

TABLE III.—AVERAGE RAINFALL FOR APRIL TO AUGUST INCLUSIVE FOR STATIONS ON OR NEAR THE MILK RIVER SHEET.

Station	Location tp., r., M.	Period of record	Average rainfall	Corres-ponding Lethbridge average	Corres-ponding Med. Hat average
Grassy Lake	10-13-4	1907-1914	4.59	8.65	6.66
Seven Persons	10- 7-4	1919-1937	7.61	8.51	7.24
Foremost	6-11-4	1920-1937 (less 3 yrs.)	8.53	9.35	7.66
Glassford	5 -7-4	1926-1936	8.35	9.24	7.79
Groton	3-10-4	1927-1937 (less 2 yrs.)	8.38	9.53	8.03
Coutts & Milk River	1-15-4	9 years	6.74	8.09	7.06
Manyberries	2- 4-4	1928-1938	6.28	8.35	6.54
Govenlock	3-29-3	1926-1936 (less 2 yrs.)	6.83	9.16	7.81
Cypress Hills	7-29-3 (mainly)	8 years	11.61	9.64	8.66

There is insufficient data from the Cypress hills to calculate any definite precipitation average. In Table III the April to August average for eight years (non-consecutive) taken at Alberta stations of about a 4,200 foot elevation indicates that the rainfall is higher than at Lethbridge and considerably higher than at Medicine Hat. It is estimated that at the top of the plateau the rainfall is at least 19.00 inches annually. The soil on this plateau indicates a fairly humid soil moisture condition.

In any discussion of rainfall it should be remembered that such factors as wind velocity, rainfall distribution, the amount of evaporation, the soil type, and the type of farm management all influence the efficiency of the rainfall obtained. The distribution of the year's rainfall in this area, as in most of Alberta, is very desirable; as stated earlier, about 75% of the total precipitation falls during the growing season and previous fall. The wind mileage and temperature are relatively high and so there is a high evaporation rate over most of the area. The heavy textured soils, in general, are more productive under limited rainfall than are the light textured soils. The light textured soils have a low water storage capacity and they give up their moisture readily.

This area receives an average of about 30 to 40 inches of snowfall annually (3 to 4 inches of precipitation). Since moisture is one of the most important factors in crop production in the Milk River sheet, conservation of the spring run-off is of vital importance. The average May rainfall at Medicine Hat is about 1.60 inches and at Manyberries 0.99 inches (ten-year average). June, however, has given 2.40 inches at Medicine Hat, 2.22 at Manyberries, and 2.30 at Foremost (21-year average). These comparisons illustrate the need to conserve the spring run-off, the need to get as much spring moisture into the soil as possible to carry the crop into June when more humid conditions generally prevail. Plowless fallow to prevent winter drifting and to hold the snow, dam listing to hold the melting snow, and contour furrows are some methods that are being tried by farmers of this area.

There is a relatively long frost free period in this area. Medicine Hat has an average frost free period of 130 days (32 years), Lethbridge 114 days (37 years), and Havre, Montana, 126 days (47 years). This is longer than the growing season for most crops, and since 1 degree ends the period in the spring or in the fall, the growing season is actually longer than the above figures indicate. There is the opinion that the frost free period on the Cypress hills is shorter than in the surrounding plains. However, since there is more moisture in the Cypress hills the crops do not mature as early and therefore may be more liable to frost damage even with the same length of frost free period.

The climate of the Milk River sheet is characterized by warm summers and relatively cold winter temperatures, subject to some fluctuation due to the influence of the chinook winds. Table IV gives the temperature records at Manyberries Range station over a ten-year period. In order to clarify the column headings the August figures may be considered.

The first column, first line, gives the mean or average August temperature over the ten-year period.

Column two, first line, gives the mean or average maximum temperature for August over the same period. It is obtained by adding the daily maxima for that period and finding the average. The mean minimum, column three, is found in like manner.

The fourth and fifth columns give respectively the warmest and coldest August temperatures recorded.

Included in this table, in columns six and seven, are the mean monthly temperatures for Medicine Hat and for Lethbridge. More complete temperature data for Medicine Hat and for Lethbridge can be found in the Rainy Hills sheet soil survey report and the Lethbridge sheet soil survey report respectively.

The yearly mean or average temperature for Manyberries for the period 1929 to 1938 inclusive is 40.4 degrees Fahrenheit. This is about one-half of one degree colder than Lethbridge and about one and one-half degrees colder than Medicine Hat. By way of comparison, Edmonton has a mean annual temperature of 37 degrees Fahrenheit. The mean temperature for the sheet is about 41 degrees. The mean temperature for the

TABLE IV.—MONTHLY, SEASONAL, AND ANNUAL MEAN AND EXTREME TEMPERATURES AT MANYBERRIES RANGE STATION, ALBERTA, 1929-1938. ALSO MEAN TEMPERATURES AT LETHBRIDGE AND MEDICINE HAT.

	Manyberries, '29-'38					Med. Hat mean '16-'33	Lethbridge mean '02-'37
	Mean	Mean Maxi-mum	Mean Mini-mum	Extreme highest	Extreme lowest		
August	66.2	81.5	50.9	98	34	67.5	63.3
September	57.5	69.3	45.7	93	10	56.5	53.0
October	43.2	56.6	29.8	84	—11	44.5	44.3
Previous fall	55.6	69.1	42.1			56.2	53.2
November	27.2	37.8	16.6	70	—26	31.0	31.7
December	17.5	25.9	9.1	57	—32	17.5	21.4
January	9.4	20.0	— 1.2	57	—44	14.5	16.3
February	13.05	23.7	2.4	67	—45	18.5	19.1
March	26.7	37.7	15.8	73	—24	30.0	28.4
Winter	18.8	29.0	8.5			22.3	23.4
April	41.0	54.2	27.8	90	—10	44.0	41.9
May	52.8	66.6	39.0	94	12	55.5	50.8
June	61.05	74.5	47.6	103	32	64.5	58.7
July	69.1	85.1	53.2	103	34	71.0	64.3
Growing season	56.0	70.1	41.9			58.8	53.9
Year	40.4	52.7	28.1			42.9	41.0

August to October period is about 55 degrees; for the winter months, November to March, about 22 degrees; and for the growing season, April to July, about 56 degrees. The extremes of temperature vary from about 105 degrees above to nearly 50 degrees below zero. By comparing the Lethbridge and Medicine Hat records there is an indication that the summers are slightly warmer and winters slightly colder in the east side of the sheet than in the west side. For December, January and February the Medicine Hat average is about 2 degrees cooler than Lethbridge, and for the months May, June, July and August, Medicine Hat is about 5 degrees warmer. In general, the summers are warm and, given sufficient moisture, permit of rapid growth. The temperature usually drops fairly rapidly after sunset making the nights cool. At Manyberries, for example, Table IV shows a 30 degree difference between the mean daily maximum and mean daily minimum for June, July and August.

VEGETATION

With the exception of the Cypress Hills area, the entire sheet is typical prairie, and supports a semi-arid prairie flora. The latter portion of the sheet is much larger and will be considered first. The Cypress Hills is a distinct area in species present and in growth characteristics. It will be dealt with last.

In general, there is a gradual change in flora from west to east. The decrease in precipitation towards the east favours the more xerophytic plant growth. However, the climatic change within the sheet is not sufficiently great to cause the disappearance of species; rather is it a matter of relative abundance. Excluding the Cypress hills, the tree growth is limited to the valley and the adjoining coulees of Milk River; balsam poplar (*Populus tacamahacca*) is the principal species. It should be mentioned that the small islands in Pakowki lake have fringes of aspen poplar (*Populus trimuloides*) along their shores. Shrubs, mainly consisting of willow species, are often associated with tree growth.

The two main grasses of the area are: blue grama grass (*Bouteloua gracilis*), a low growing fine-leaved grass with a curved type head which becomes a deep purple on curing; and common spear grass (*Stipa comata*), the common name being derived from the long curled awn with minute barbs along its edges which is a striking characteristic of this grass. Blue grama grass is possibly the more valuable of the two, for, in the later stages of growth the spear-like awns of the spear grass tend to work into the fleece of grazing sheep. Stockmen claim, however, that spear grass is especially valuable for winter pasture since the seeds with their awns fall to the ground and the remainder of the plant is good forage. Actual plant counts in the area have shown in most cases that there is a greater coverage of blue grama grass per unit area, but it possibly does not provide quite as much forage as the spear grass due to the former's finer habit of growth.

Other grasses approximately in order of relative importance are: June grass (*Koeleria cristata*), a fine-leaved grass with a compressed panicle type head; Sandberg bluegrass (*Poa secunda*), a small low growing tufted grass having good forage value; bluejoint (*Agropyron Smithii*), a medium sized rather coarse grass having a true spike head (this plant is more common in small local depressions than on the higher land); plains reedgrass (*Calamagrostis montanensis*), a plant much resembling June grass but slightly larger; and green spear grass (*Stipa viridula*), a low-growing awned grass slightly smaller and having much smaller awns than common spear grass. Smooth wheatgrass (*Agropyron pauciflorum*) is quite common on the higher land but does not occur on the low spots since it tolerates very little alkali. Tufted hairgrass (*Deschampsia caespitosa*) is often associated with bluejoint in the local depressions. Sand grass (*Calamovilfa longifolia*) a tall coarse-growing grass is common in sand areas and acts as a binding agent. It has little forage value due to its coarse growing habit. Indian rice (*Oryzopsis hymenoides*) is often found associated with sand grass.

Two species of sedge of forage importance should be mentioned. These are commonly grouped together and called niggerwool; the specific names are *Carex filifolia* and *Carex heliophila*. Both species occur as a short dense wiry growth, Two herbaceous shrubs common especially in the drier south-east section, have some forage value. The first and most important is winterfat (*Eurotia lanata*), a small grey, low-growing sage-like plant that is said to have value for winter forage. The second is salt sage (*Atriplex Nuttallii*), a small low-growing shrub common in slightly alkaline depressions.

Common club moss (*Selaginella densa*), a small low-growing club moss which spreads in patches over the ground surface to the exclusion of forage plants, and prairie phlox (*Phlox Hoodii*), which is more upright and lacks the creeping qualities of the common club moss, both tend to increase in number in the drier south-east portion of the sheet. Both of these plants reduce the forage value of the land. Cacti also become increasingly common in the south-eastern portion. There are two species (*Opuntia polyacantha*), a large spreading yellow-flowered type and (*Opuntia neomanillaria*), a small cushion-like species with a small red flower.

The common weeds in the cultivated areas are Russian thistle, stinkweed and tumbling mustard. Other plants with little or no forage value common in the area are: pasture sage (*Artemisia frigida*); silver sage (*Artemisia gnaphalodes*); sagebrush (*Artemisia cana*); broomweed (*Gutierrezia diversifolia*), a small, low-growing yellow flowered plant; gum-plant (*Grindelia spp.*), a tall yellow flowered plant which secretes a gum-like substance; prairie cone flower (*Lepachys columnifera*), and buckbrush (*Symphoricarpos occidentalis*); greasewood (*Sarcobatus vermiculatus*) is found in many of the alkaline coulees. Very little else grows on these greasewood flats. Wild licorice (*Glycyrrhiza lepidota*) is found in many areas, especially if the soil is sandy. This plant is said to grow only in locations where the water table is within the reach of the roots which, however, will penetrate to a depth of twenty feet. Low juniper (*Juniperus*) was found growing on the eroded spots of bed rock.

Some mention should be made of plants poisonous to livestock that were found in the area. At least three such plants are found in the vicinity of the Dominion Range Experiment Station at Manyberries. It has been observed that livestock tend to avoid such forage unless the pasturage becomes too limited. The narrow-leaved milk vetch (*Astragalus pectin-*

atus) (Dougl.) occurs over most of the area. It is a spindly growing plant with short broad curved seed pods. The twin-grooved milk vetch (*Astragalus bisulcatus*) (A. Gray) appears to be limited in distribution to the southeastern portion around Manyberries, occurring both as scattered plants and as dense patches a quarter acre or more in size. Analyses of these plants show the element selenium to be present in highly toxic quantities, although the soils upon which they grow showed a low selenium content. The element selenium in plants is extremely poisonous to animals and has been shown to be the cause of "alkali disease". Death camas (*Toxicoscordion gramineum*) which contains a toxoid poison also occurs in the area.

The Cypress Hills area, as previously mentioned supports a plant growth markedly different from that found on the surrounding prairie due to a much higher precipitation; the annual total reaches about 19 inches at the top of the plateau. Timber of some commercial value is found within the forest reserve boundaries. Lodgepole pine (*Pinus contorta*) forms the principal tree growth (see plate 3, fig. 2), with aspen poplar (*Populus tremuloides*), spruce (*Picea canadensis*) and black poplar (*Populus balsamifera* and other species), all common. The greatest tree growth is on the north escarpment. There is a heavy growth from the edge of the plateau to the base (down to about the 4,200 foot contour); the growth on the south escarpment does not reach as low an elevation as on the north escarpment. Some of the coulees at the east end of the plateau are fairly heavily wooded. Very little tree growth occurs on top of the plateau below the 4,500 foot level. Associated with the dense tree growth are such woody shrubs as saskatoon, chokecherry, willow (*Salix spp.*), low juniper, bearberry (*Arctostaphylos Uva-ursi*), and bull berry (*Shepherdia canadensis*). In the open areas where only scattered trees occur, shrubby cinquefoil (*Dasiphora fruticosa*), a small woody shrub, is a serious pest and reduces the grazing value of a large portion of the area (see plate 3, fig. 1).

Probably the dominant grass of the Cypress area is blue-bunch fescue (*Festuca idahoensis*). Among others *Festuca scabrella, Stipa spartea var. curtiseta, Koeleria cristata,* and species of Agropyron and Poa were all found in varying numbers. Wild oat grass (*Danthonia intermedia*) is a characteristic plant of this more humid area. Some of the plants found on the surrounding plains are present on the drier slopes of the hills. Along the roadsides many plant species occur which have evidently grown from transported seed, e.g., timothy (*Phleum protense*), brome grass (*Bromus inermis*), slender wheat grass, and some species of Elymus.

SYSTEM OF SOIL CLASSIFICATION

The soils of Alberta are divided into broad soil zones. The zonal divisions are based principally on the color of the soil profile; these color differences having developed as the result of certain soil moisture and vegetation conditions over a long period of time. The soils of the respective zones are again divided on the following bases: the texture of the surface soil, generally of the A horizon; the dominant characteristics of the soil profile; and the mode of deposition of the parent material, that is its geological deposition. Such factors as topography, stoniness, alkali accumulation, grass or tree growth and degree of erosion all influence the soil type finally designated. The combination of all the factors that characterize a given soil, other than its surface texture gives that soil its series designation. Most of the soil of the Milk River sheet is in the brown soil zone. However, islands of darker soil are mapped at the base of Sweet Grass hills and on the Cypress hills. On the map accompanying this report the soil classes, determined by the surface texture, are shown in different colors. Each textural class, however, may be subdivided into smaller areas, and each of these areas carries a three digit number. This number determines its series. Although the complete legend for the classification of the soils of this sheet appears on the map, an explanation of that legend is in order here to facilitate the interpretation of the next section in this report, namely, the soils of the Milk River sheet.

Soil Zone.

The 1.0.0 soils are those in the brown soil zone. This zone corresponds to the bald prairie of southeastern Alberta. These soils are relatively low in nitrogen and have a shallow profile. They have developed under a low annual rainfall and a relatively high evaporation.

The 2.0.0 soils are those in the dark brown soil zone. This zone forms a broad transition belt between the brown and black or parkland soils of the province and has developed under somewhat more humid conditions than prevail in the brown zone.

The 3.0.0 soils are those in the shallow black soil zone. Although formed under a fairly high annual rainfall, a relatively high evaporation rate has restricted the accumulation of organic matter, and a shallow profile with a correspondingly shallow black A or surface horizon has developed.

The 4.0.0 soils are those in the black soil zone. These soils have a fairly deep profile and a black A horizon usually 8 to 12 inches deep. They have developed under a fairly humid soil moisture condition. As stated earlier in this section the 2.0.0, 3.0.0 and 4.0.0 soils of this sheet are found as isolated islands associated with land of relatively high elevations and form only a small percentage of the total acreage. These islands do not connect with the main dark brown or black zones of the Prairie Provinces.

The 5.0.0 soils are somewhat degraded, the result of podsolization. Only a small area of 5.0.0 was mapped on the Milk River sheet and no definite definition of this type has yet been established.

Mode of Deposition of Parent Material.

This column deals with the parent material on which the soil profile developed. Glaciers, wind and water all played a part in the transporting and sorting of this parent material. In many cases it is impossible to determine what agency has been most active. In this classification certain type profiles most characteristic of the mode of deposition were set up. It is possible that in many cases the geological agency indicated in the legend may not have been solely responsible for the deposition of the parent material.

0.0—These soils are residual soils, that is soils formed in situ from the weathering of the underlying rock formations. Since most of the consolidated rock formations of Alberta were formed in the beds of large bodies of water, this material is relatively stone free and the soil profile that has formed from their weathering is also stone free. An exception to this occurs in the Milk River sheet. The top of the Cypress hills has not been glaciated and the soil profile has formed on the weathered tertiary bed rock which in this case is a conglomerate. This conglomerate is composed of water-worn rocks varying in size from sand grains to nearly twelve inches in length. In most cases the topography is level to undulating, and the unweathered parent rock is quite close to the surface.

1.0—These soils are termed sorted residual. They are formed principally from the weathered material of the underlying parent rock that has undergone some surface sorting. Many of these soils may have been glaciated at one time, but the glacial till has all eroded off, leaving only the transported stones on the surface. The depth of unconsolidated material over the parent rock varies greatly, but in these areas exposures of the underlying formation are quite numerous, and undisturbed parent material is often found within the profile depth.

2.0—These soils are unsorted glacial soils, that is soils which have developed on the unsorted till just as the receding ice left it. These soils are characterized by a rough topography and few to many stones scattered throughout the profile. Due to the broken nature of the topography and the absence of gravel and sand lenses, the areas often contain numerous sloughs and meadows. The till or glacial drift in this area was mainly transported by the Keewatin glaciations. Some of the material naturally is of local origin, but some has been transported long distances. Because of the variety of sources of this material the texture of these soils is often quite variable.

3.0—These soils are termed resorted glacial. They have developed on glacial till that has undergone a surface sorting. Generally these areas are on level to undulating topography, that is on ground moraine. There are glacial stones throughout the profile, particularly in the unsorted subsoil, and the surface material may contain some water-worn gravel and stones. Wind, as well as water, may have been responsible for the formation of this surface layer. Generally these soils are of a more uniform surface texture than the glacial soils and agriculturally are generally good soils.

4.0—These soils are a grouping under the title, gravelly outwash. They are characterized by being very gravelly and often stony. In most cases they are non-arable. The gravelly nature may be due to an alluvial deposition or to the removal of the finer particles from glacial dumps. In either case the coarse gravel and stones predominate due to the washing out of the finer material. They are generally light textured soils and have level to undulating topography.

5.0—These soils are of alluvial original. They are characterized by the presence of some water-worn stones in the profile and by the presence of gravel and sand lenses throughout the profile. The variable deposition is the result of water moving at different speeds or carrying loads of varying materials. These soils vary in their utility with the percentage of gravel and the frequency of sand lenses. These sandy lenses affect the drainage and the water holding capacity of the soil.

6.0—These soils may be alluvial or eolian. In this class are put the fairly uniformly deposited soils. Generally they are medium to light textured. In many cases these soils are of alluvial origin, but have been subsequently moved by wind. They are generally stone free and have undulating to gently rolling topography.

7.0—These soils may be lacustrine or eolian. In this class are put the uniformly deposited soils. Generally they are medium to heavy textured. Most of the soils of this class are of lacustrine formation, that is, they have formed on the material that settled out of still water. As a result the texture of these soils is fairly uniform throughout the profile. They are practically stone free and generally have level to undulating topography. Post-glacial winds may have been responsible for deep silt deposits, particularly in the glaciated areas. In general this eolian deposition is shallower than the average lacustrine deposition.

Profile Variation.

This column deals with the variations that are found in profile development as well as the degree of salinization of the soil. Chemical and physical weathering of the parent material, the movement of soluble substances throughout the soil profile by the percolating rain water, the addition of organic matter due to vegetative growth, and the activity of soil micro-organisms are some of the important agencies that have created the soil profile.

0—These soils have very little profile development. The sands, recently flooded river bottoms, and areas that have recently been severely drifted, lack profile development. They may be considered as raw or undeveloped, and in general have a single grained structure.

1—These soils are hillside soils. As a result of loss of run-off water these soils are locally more arid than the surrounding soils and generally they are of a lighter color and have a shallower profile. The run-off water carries with it much of the surface soil from the slopes.

2—These soils are non-saline and have a normal profile development; that is, they are normal for their texture and the amount of rainfall they receive. The structure is commonly cloddy to columnar. They are generally the good arable soils.

3—Soils of profile 3 are non-saline, but are developed in local depressions. Due to a lower position they receive run-off from the higher soils nearby and as a result may develop a deeper and darker profile than the normal soils of the area. If these soils do not have a drainage problem they are among the best arable soils.

4—These soils are characterized by a weak solonetz development. They have a well developed columnar B_1 horizon, but the white rounded tops and the break between the A_2 and B_1 is not so clearly defined as in 6. They are intermediate in character and utilization between soils 6 and 2.

5—These soils are slightly saline and are generally found in areas that have poor to fair drainage. Due to the poor drainage a normal soil profile does not develop and the profile has very little differentiation from the surface down. They are often of quite a heavy texture. The alkali salts move up and down in the soil depending on the direction of the movement of the water in the soil. Many of these grow good meadow hay and some might produce certain cultivated crops if properly drained.

6—These soils are slightly saline, but generally less so than the soils of 5. They are characterized by a hard impervious subsurface layer—a solonetz like B_1 horizon. The hard B_1 horizon has a well developed columnar structure and the surface of this horizon often looks much like a cauliflower head. The A_2 horizon that lies immediately above this layer is often very light in color and of a layered or platy structure. Although there are exceptions, most of the solonetz-like profiles are found on level to undulating areas where possibly at one time drainage was not adequate. The areas are often characterized by a patchy micro-relief due to the erosion of the A horizon. If the hard layer is close to the surface they are generally inferior soils, partly because of the limited depth of water and root penetration.

7—These soils have a high concentration of lime carbonate practically to the surface and are, in general, much lighter in color than the soils normal for the area. Many of these soils have a lifeless appearance and are generally of low productivity.

Each soil area outlined or described, then, carries a three digit number. Each of the digits is separated by a dot, for example, 1.2.1. This number represents a brown, glacial soil profile developed on sloping ground. It is quite possible that two modes of deposition may be found, one over the other within the profile depth; for example, it is possible to have an eolian deposition over glacial till. This would carry the deposition number 6/2. Some large areas in this sheet have been mapped as 2/0. In most of these areas there are patches of glacial till still remaining over the residual parent rock. It should also be recognized that the profile development in a given soil area is not entirely uniform. If one form of development is quite dominant, a single number is used in the units column. However, if there are two distinct forms of development so intermixed that separation is not practical, a fraction may be used in this column. For example, the complex 2/6 would indicate a normal soil profile over most of the area with patches of solonized soils scattered throughout the area. Such a soil area might carry the number 2.1.2/6. This indicates a dark brown soil formed on sorted residual parent material having generally a normal profile development, but containing patches of solonetz soils within the area.

There are eight main texture classes mapped. These are, going from the lightest to the heaviest, sand, sandy loam, fine sandy loam, loam, silt loam, silty clay loam, clay loam and clay. There is also a mixed class that is used where the surface is so badly mixed that separation is not practical. Some of these classes are subdivided into light medium and heavy phases; on the map Lt. refers to the light phase and H. to the heavy phase. Descriptions of these soil textures are found in the soil section of this report (see page 33).

Topography, the presence of eroded surface patches in the solonized soils, and rock outcrops are indicated on the soil map by symbols.

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. It should also be noted that in a survey such as this one, small areas could not be outlined. Hence, although the extensive soil types are outlined fairly accurately, the map should not be depended upon without further inspection for the soil type of individual quarter sections.

SOILS

With the exception of the Cypress hills plateau, the Milk River sheet was practically all covered by the Hudson Bay glaciation: McConnell stated that he found no evidence of glaciation on the Cypress hills above the 4,400 foot contour. In many places on this sheet the glacial till has been eroded off leaving only the glacial erratics scattered over the surface and the soil profile has been formed of weathered, and often sorted, residual material. This residual or parent rock is of upper Cretaceous age and is principally Bearpaw shale and Belly River sandstone (see plate 4, figs. 1 and 3). Pakowki shale and Milk River sandstone (see plate 2, fig. 1), however, are the uppermost rock in the southwest corner of the sheet and Lower Ravencrage is found immediately adjacent to the Cypress plateau. The Cypress plateau is of Tertiary age and is capped with a deep deposition of Cypress conglomerate (see appendix by J. A. Allan). This plateau is mapped as residual soils. The surface soil covering the conglomerate varies from a few inches to three or four feet in thickness (see plate 2, fig. 2). The stony nature of this profile makes it unlike most of the residual soils that have been mapped, to date, in Alberta.

In general, the soils south of a line drawn from Cypress hills through Manyberries to the south end of Pakowki lake and then south to the international boundary, plus a strip along each side of Milk river as far west as tp. 2, range 13, have been mapped as residual, sorted residual and glacial residual. Over practically this entire area, as outlined above, the soil profile has been influenced by the parent rock. The consolidated parent rock can usually be found from a few inches to a few feet below the surface.

Deep moraines are not common in this sheet. The rolling area north and south of Etzikom and the gently rolling to rolling area adjacent to Etzikom coulee, in the west half of the sheet, are the most pronounced glacial moraines. There has also been some dumping of glacial till south of Milk river at the base of the Sweet Grass hills. The till in these areas is quite stony and generally fairly heavy textured.

North of Chin Coulee, as well as a narrow strip south of the coulee as far east as Nemiscam, the till mantle is relatively thin and has been subjected to considerable post-glacial sorting by wind and water. There is a large acreage of fairly uniform light textured soils in this area, suggesting a wind sorting of or a deposition on the ground moraine. Between Fortymile and Seven Persons coulees there has been considerable stream action. This is indicated by small sandy areas and by gravel lenses in the profile.

No large post-glacial laking areas have been mapped. One narrow strip of heavy textured water laid soil is mapped just east of Seven Persons coulee and south towards Pakowki lake. This area may at one time have been the course of a northern outlet of Pakowki lake. The silt loam area immediately adjacent to Foremost has been mapped as glacial lacustrine. This area lies at the eastern end of the large sorted glacial area described above. Two other laking areas are mapped, one is associated with the dry bed of Pakowki lake and the other with the beds of Sage and Milk River lakes in tp. 1, range 2.

There are no large sand areas in this sheet. A small area of dune sand is mapped along the northeast shore of Pakowki lake. A few small patches of light textured soils of alluvial deposition are also mapped. The large acreage of fine sandy loam in the southeast portion of the sheet mapped as sorted residual owes its sandy character to the Belly River bedrock from which it is formed.

The data in Part I of Table V gives the acreage and percentage distribution of the main topographical types on the Milk River sheet. There is very little level land on this sheet; the area immediately south of Foremost, the top of the Cypress plateau, and Pakowki lake flat are three of the larger level areas. On the soil map the level and undulating topography classes are not separated. The principal reason for this is that, under dry land agriculture there is very little difference between them in their utilization value. From Table V it is seen that 32.6% of the sheet is mapped as level and undulating. The largest block of this topography class is in the northwest portion of the sheet, carrying as far east as Nemiscam. Another fairly large area lies immediately north of Verdigris coulee. Smaller areas are outlined west of Pakowki lake, south of Milk river in tp. 2, ranges 9 and 10, in tp. 1, range 2, and south of Orion.

About 36% of the sheet is mapped as gently rolling. Land of this topography class offers very little obstruction to cultivation, the slopes are gentle and, in general, the hills are low. There is more gently rolling topography mapped than any other topography class and it is found scattered over most of the sheet. The largest individual area lies between Etzikom coulee and Milk river west of Pakowki lake. Fairly large areas are also found in the southeast corner of the sheet, southeast of Manyberries, and adjacent to Fortymile and Seven Persons coulees. In fact, excepting the northeast corner associated with Cypriss hills the entire sheet could be given the general topography description of gently rolling.

TABLE V.—EXTENT OF TOPOGRAPHY DIVISION AND SOIL CLASSES IN THE MILK RIVER SHEET

PART I—TOPOGRAPHY DIVISION

Division	Acres	Per cent.
Hilly	195,000	7.0
Rolling	335,000	12.1
Gently rolling	1,005,000	36.0
Level to undulating	890,000	32.6
Eroded land	300,000	10.9
Water and marshes	40,000	1.4
Total	2,765,000	100.0

PART II—SOIL CLASSES

Soil Class	Acres	Total
BROWN SOILS:		
Sand	10,000	
Sandy Loam	24,000	
Fine Sandy Loam	117,000	
Light Loam	216,000	
Loam	661,000	
Heavy Loam	561,500	
Silt Loam	115,200	
Clay Loam	375,000	
Silty Clay Loam	4,000	
Clay	92,000	
Mixed	10,000	2,185,700
DARK BROWN:		
Light Loam	1,600	
Loam	67,500	
Heavy Loam	93,000	
Clay Loam	4,500	
Clay	2,500	169,100
SHALLOW BLACK:		
Loam	17,000	
Heavy Loam	4,500	
Silt Loam	39,500	
Clay Loam	1,100	
Clay	800	62,900
BLACK:		
Loam	400	
Silt Loam	2,200	2,600
TRANSITION:		
Loam	1,700	1,700
Water and Marshes		40,000
Eroded Land		300,000
Total		2,762,000

Rolling land makes up 12.1% of the sheet. Rolling land is, other conditions being favorable, possible of cultivation. However, in the brown soil it is rarely better than poor arable land. It includes low choppy hills and fairly high ridges with a uniform slope. Cultivated areas of rolling topography generally cost more to farm than the more level areas; they are subject to greater water erosion, and the crops tend to ripen unevenly. In general, the rolling areas in this sheet are relatively small, and are the rougher portions of the main gently rolling areas. The two largest rolling areas are the foothills of the Sweet Grass hills and the morainal area adjacent to Etzikom.

Hilly land makes up 7.0% of the total area. Hilly land is recognized, excepting under unusual circumstances, as being too steep to cultivate. In the hilly areas, however, there may be some arable patches, particularly in the valleys. With the exception of a few small patches, most of the hilly land lies in the northeast portion of the sheet along the edge of the Cypress hills plateau. The main area starts just east of Manyberries, goes north to Eagle Butte and Rush lake and then carries around the north edge of the plateau. Much of this hilly land is formed by the differential erosion of the residual beds.

Erosion makes up 10.9% of the total area of the sheet. Water only makes up 1.4% of the total area. These last two are described under separate headings later in this report. The above topography classes are shown on the soil map that accompanies this report.

The data in Part II of Table V show the acreage distribution of the textural soil classes on the Milk River sheet. From this table it is seen that loam textured soils make up the greatest percentage, approximately 58.9% of the total area. Loam soils are medium textured soils generally underlaid by a subsoil heavier than the surface soil. A true loam soil has the three fractions, sand, silt, and clay, mixed in such proportions that no one fraction predominates. Mechanical analyses of seven surface heavy loam samples gave an average of 44% sand, 46% silt and 10% clay less than 0.002 mm. in diameter, or 17% clay less than 0.005 mm. Analyses of three loam soils gave an average of 52% sand, 41% silt and 7% clay, or 13% clay less than 0.005 mm. The light loams have more sand and less clay than the medium loams. A fairly large percentage of the soils of this area is graded a heavy loam. This class includes loams that are heavy due to a fairly high clay content and loams that have a fairly high silt content. In other words the heavy loam class includes those soils that fall between loam and clay loam, or between loam and silt loam. Loam soils generally do not drift as readily as do the soils of either a lighter or a heavier texture; they are relatively fertile and in areas other than those of restricted rainfall are often good arable soils.

Clay loam forms about 13.8% of the total area. The clay loam soils of this sheet average between 15 and 25% clay particles, less than 0.002 mm. Mechanical analyses of four surface clay loam samples from this sheet averaged 38% sand, 46% silt and 16% clay, less than 0.002 mm. or 25% clay less than 0.005 mm. Much of the morainal till north of Etzikom and adjacent to Etzikom coulee is mapped as clay loam. Clay loams are generally intermediate in utilization between heavy loams and clays.

Silt loam forms approximately 5.7% of the total area. Silt loam soils have a predominance of silt particles in their mechanical composition, usually over 50%. Mechanical analyses of four surface silt loam samples gave an average of 38% sand, 52% silt and 10% clay, less than 0.002 mm. or 19% clay less than 0.005 mm. This would make the silt fraction in the second case 43%. Actually there are very few real silty, lacustrine deposition areas in this sheet, and most of the silt loam areas are the light phase of this texture class, associated with eolian and alluvial deposition. Silt loam soils usually have few to no stones. They are not as heavy to cultivate as the clay soils, but they have a high water retention power and are usually well supplied with available plant food elements; as a result of these factors they are generally among the best arable soils. There are fairly large areas of silt loam outlined in the northwest corner of the sheet and on the Cypress plateau. Silty clay loam is a soil having a fairly high percentage of both silt and clay and is definitely heavy. There are praceically no silty clay loam soils outlined in this area. Only 0.1% is mapped as silty clay loam and these are really bottom soils and are often alkaline.

Clay forms approximately 3.4% of the total area. Clay soils contain about 25% or more of clay particles, less than 0.002 mm., and are therefore definitely heavy soils. Clay areas are generally associated with laking, the fine particles having settled out of still water. Clay soils with a normal profile are good dry land soils. They have a high water holding capacity and generally contain a fairly large amount of available plant foods. Under irrigation these heavy soils may be difficult to work and may bake with excess water. Clay areas are mapped in Pakowki lake flats, east of Seven Persons coulee and in some of the valleys, particularly in the east half of the sheet.

About 4.0% of the area is mapped as fine sandy loam. Fine sandy loam soils contain about 65 to 75% sand. They do, however, usually contain enough of the finer soil particles to give the profile some firmness, and they may be fair arable soils excepting under quite dry conditions. A large area of fine sandy loam is mapped in the southeast corner of the sheet. These are mainly residual soils associated with the Belly River sandstones.

About 0.9% of the area is mapped as sandy loam and 0.4% as sand. Sandy loam soils contain about 80 to 85% sand and the sands about 90%. Soils of these textures are usually of alluvial or eolian deposition. In the dry areas, they are, excepting under unusual circumstances, non-arable. They will drift readily and are often low in fertility. There is a fairly large area of sand and sandy loam mapped along the north and east side of Pakowki lake.

About 0.4% of the area is mapped as mixed soils. They are principally those river bottom and coulee draw soils that it was found impractical to separate, mapping on the scale of three miles to the inch. Some of these areas are liable to flooding during a heavy spring run-off.

On the soil map that accompanies this report the soil textures are designated by different colors. Each soil area on the map carries a three digit number; this number indicates the soil series to which the area belongs. The first or hundreds digit refers to the color zone, the second or ten digit refers to the way the parent material, upon which the soil profile has formed, was deposited, and the third or unit digit indicates the form of profile that has developed. In the section on "System of Soil Classification" these factors were broadly defined and the method of using them indicated.

Although four color zones are mapped in this sheet the major portion of the sheet is in the brown soil zone. These color zones have developed as a result of different soil moisture relationships; for example, the brown soils of this sheet have been formed, over a long period of time, under drier soil conditions than those forming the black soils on the Cypress plateau. Drier soil conditions may be due to lower rainfall, higher temperature, or a greater evaporation, or a combination of these factors. The dark brown soils around the Sweet Grass hills jut into the Milk River sheet in ranges, 10, 11, 12 and 13, and carry north for about one-half to two-thirds of a township, that is, portions of tp. 1 in the above ranges are dark brown soils. The line dividing the brown and dark brown soils along the base of the Cypress hills enters the sheet on the west side of tp. 8, range 6, extends in a southeasterly direction to the southwest corner of tp. 6, range 3, and then turns east by northeast to leave the sheet at the northeast corner of tp. 6, range 1. The line dividing the dark brown from shallow black soils occurs just outside the forest reserve boundary on the north side, taking in most of tp. 8 in ranges 1, 2 and 3, passes through the northeast corner of tp. 7, range 4, then southeast to the northeast corner of tp. 6, range 3, and then east by northeast to leave the sheet in the centre of tp. 7, range 1. This line follows fairly closely the 4,200 foot contour. The top of the plateau in tp. 8, range 3, is mapped as normal black. This area is in general above the 4,500 foot contour. Although no zone line is drawn, much of the soil on the wooded slopes leading from the Cypress plateau is podsolized and is very light colored. In a survey carried out in much more detail than this one, it might have been possible to separate the large brown soil zone into two areas. It can be stated, however, that the soils lying west of a line drawn along Fortymile coulee to Pakowki lake and then southwest to about tp. 1, range 13, are, in general, slightly darker in color and slightly higher in organic matter than the brown soils lying east of this line. It must be recognized that most color lines represent a fairly broad strip of land; that is, there is a gradual change from one zone to the next. In this sheet, however, the change from one soil color zone to the next is very sharp, this being due to the rapid increase in elevation that accompanies the soil color changes. It should also be stated here that the darker colored soil areas in this sheet are in the nature of islands within the brown soil zone and are not connected with the main dark brown and black soil zones of Alberta. The darker soil areas of both the Sweet Grass hills and the Cypress hills are due to a moister soil condition caused by the relatively higher elevations of these areas.

The color of the soil, the method of deposition of the parent material, and the type of profile all imprint certain characteristics on the final soil area; each factor contributing to the soil's morphology and to its utilization. It must be recognized that natural objects, and soil is a natural object, commonly do not fall into hard and fast classifications. There are variations within any given series and within any given type, and one series or type gradually changes into another. Such variations must be expected in any soil area, but in general the variations are small and within any given soil boundary the profiles do not deviate far from the average for that particular area.

In the description of the soil areas of the Milk River sheet the following arrangement is made:

The areas are first divided into three groups, namely, the areas of the brown soil zone, the dark brown soil sub-zone, and the black soil sub-zones. Then the major soil areas or groups within these color zones are described. These major areas include, in a general way, those soils that are somewhat similar in morphology and in utilization. Following these descriptions there are tables in which the principal characteristics and total acreage of each series type are listed. In these tables the following abbreviations are used: In the location column the first numbers refers to township and the second to range; in the topography column L. is level, U. is undulating, G.R. is gently rolling, R. is rolling, and H. is hilly. In the classification column Pr. is poor, F. is fair, F.G. is fairly good, G. is good, V.G. is very good, P. is pasture, and A. is arable.

BROWN SOIL ZONE

In general the brown soils are characterized by a shallow profile and a light color. The brown color of the "A" horizon indicates that these soils are relatively low in organic matter content when compared with the soils of the more humid sections of the province. These soils are fairly well supplied with the mineral constituents and in years of sufficient rainfall there has been enough available plant food to produce good growth. The lime carbonate horizon is found at from 9 to 24 inches and average about 12 inches from the surface in this area (see plate 6, fig. 1). In the west half of the sheet it averages about 12 to 13 inches and in the east half about 11 inches. The Milk River sheet is well within the brown soil zone, and with the exception of two islands of darker colored soil all soils on this sheet are brown. The brown soils of this sheet have been formed under a rainfall of from 12 to 14 inches with a fairly high evaporation rate. It has been stated in the section on "Soils" that a triangular area having its base along the west side of this sheet and its apex at Lake Pakowki is in general darker colored than the brown soils outside of this triangle. In general the soils inside this triangle are brown and those outside are from brown to light brown and the average nitrogen content of the first named area is higher than that of the second area. The change from brown to dark brown in the two islands of darker soil is very rapid, due principally to the rapid change in elevation that is associated with these darker soil areas.

Below is given a description of the major soil groups of this zone; the descriptions are principally on a utilization basis. Table VI gives the main characteristics of each individual soil area.

Fine Sandy Loams of the Southeast Corner.

Lying in township 1, ranges 1 to 5 inclusive (excluding the clay laking basin in tp. 1, range 2) is an area of residual and alluvial light textured soils. The western portion is graded a 1.0.2 fine sandy loam, that is a residual soil with normal profile development. The area in general is a level crown practically stone free. It appears that the soil profile is formed from the weathered Belly River sandstone; consolidated sandstone rock is often found within the profile depth. The relatively light texture of the surface soil, the nearness of the bed rock and the proximity to deep erosion coulees makes this soil type pasture land. It is supporting a fairly good growth of grass at present.

East of the residual fine sandy loam are areas of 1.5.2 fine sandy loam. These are of alluvial deposition. In this area the drains from the higher land to the north spread out, the coarser material being dumped as alluvial fans and alluvial flood plains. Although in general having a deeper profile than the 1.0.2 to the west the light texture of the surface as well as the porous nature of the subsoil, makes this soil type in general pasture land. Near the edge of the laking basin areas of 1.6.0 sandy loam are found.

Scattered throughout this area are lower areas of heavier textured soils that in the main have hard solonized profiles.

Heavy Textured Laking Basin in the Southeast Corner.

Lying principally in tp. 1, range 2, is a large area of 1.7.2/5 clay. This is a level lacustrine area in which the fine materials carried from the higher land to the northwest have been deposited.

The percentage of alkali salt in the area varies. At least two patches contained a high enough content of salt to practically inhibit any native vegetative growth. Other portions have a considerable grass growth and under flood irrigation have become relatively productive hay meadows. In general the greatest salt content is found towards the lower or southern end of the basin. Portions of the basin contain a fairly deep deposition of very fine sand often lensed in with the clay. The 1.7.2 silt loam which forms part of this basin is principally very fine sand.

Excluding those portions that are definitely alkaline and often extremely heavy textured, the remainder of the area has arable possibilities particularly under a system of flood irrigation.

Residual Solonized Loams Southeast of Manyberries.

Lying east of Manyberries principally inside a quadrangle whose four corners are located approximately as follows: tp. 1, range 1, tp. 2, range 5, Manyberries, and tp. 6, range 1. The soils in this general area are mainly 1.1.6, 1.2/0.6 and 1.2/0.2/6 loams and light loams, and 1.0.6 clay loams. That is, the soil profile is definitely associated with the residual rock formation, which in this case is principally Bearpaw shale. Practically all the areas have a solonized profile with characteristic eroded pits due to the patchy removal of the "A" or surface horizon. This loss of "A" horizon varies from about 10 to 15% in the 1.2/0.2/6 loam to about 75% in the 1.0.6 clay loam.

Glacial erratics of Hudson's Bay origin are scattered over this entire area, but they are mostly on the surface. Particularly in the north half of this area there are many small water washed stones. These are quite similar in appearance to the stones in the remaining Cypress conglomerate found on the plateau. In the 2/0 areas, this is glacial residual, low ridges or knolls of glacial till remain, but in general, the till covering has all eroded off leaving only the surface erratics.

The entire area slopes gently to the southeast and is cut by wide deep erosion channels. The topography is mainly undulating to gently rolling and the long uniform sweeps suggest an eroding off of the parent rock. Most of the mapped erosion in this area is bare exposures of parent rock almost devoid of vegetative growth.

The following profile taken in section 35, tp. 2, range 1, is fairly typical of the loams and light loams of this area:

0″-2″—A_1. Fine sandy loam texture, loose, brown to light brown in color.

2″-3″—A_2. Light brown color. Somewhat platy.

3″-6″—B_1. Dark brown color and of a sandy clay texture. Columnar, breaking into large cubes with waxy surfaces.

6″-12″—B_2. Similar structure to B_1 but contains a little lime deposition.

at 16″—C. Hard massive to cloddy structure. Nearly black in color.

In the eroded pits the A_1 and most of the A_2 horizons have been lost and the hard B_1 is exposed to the surface. This exposed subsurface may or may not support grass growth. In general the top of the hard solonized B_1 columns are flat and quite clearly separated from the overlying A_2; in places, however, these column tops are rounded and very hard. Rarely is there a heavy deposition of lime but some effervescence can be obtained at depths varying from 6 to 16 inches. In general the "1" deposition areas, that is the sorted residual, have a deeper more uniform profile than the 2/0 areas. Due to the sloping nature of the area, the hard solonized profile, the very limited rainfall of this section, as well as some other factors, these loams are generally non-arable but are fair to fairly good pasture. Blue grama grass, spear grass, and nigger wool (a grass-like sedge) form the principal grass growth.

In this general area is a fairly large acreage of 1.0.6 clay loam and stony clay loam. In these areas the process of surface erosion is still progressing quite rapidly with the result that there is a very shallow profile over the parent shale. The A horizon is practically absent and the exposed B_1 horizon, still retaining the dark color of the parent Bearpaw shale, supports very little grass growth. These areas are in general poor to fair pasture (see plate 4, fig. 2).

Although stock water supply is a problem in parts of this general area, there are many available cites for coulee dams to hold the spring run-off water. The supply of available coulee flats with good irrigable possibilities is limited. The major portion of these flats are washed and have a fairly high salt content. Some small alluvial fans have arable possibilities.

Solonized Sorted Residual Loams between Pendant d'Oreille and Comrey.

Lying adjacent to Pendant d'Oreille and Comrey and bounded on the west by Pendant d'Oreille coulee, on the northeast by Lost River and on the south by Milk River, is an area of loam soil with varying amounts of solonized profiles. The underlying parent rock of Belly River sandstone is relatively close to the surface over practically the entire area. Immediately adjacent to Pendant d'Oreille coulee is a strip of 1.2.2 loam and heavy loam. In this portion there appears to be a fair depth of glacial till. In the glacial-residual (2/0) areas, there are ridges and knolls of glacial till still remaining. Stones are generally few throughout the area.

The topography is undulating to hilly. Most of the rolling to hilly land is adjacent to Milk river and here much of the topographical irregularities appear to have resulted from the eroding away of the parent bed rock. The slopes of the hills are long and uniform. They support a fairly good growth of grass.

Some areas are given the profile designation 6 and some the designation 2/6. In the 2/6 areas there is between 5 and 15% of solonized profiles with a somewhat similar percentage of surface erosion. The remaining 85 to 95% of these areas have a normal (2) profile.

The area of 1.1.2/6 loam in tp. 2, range 6, known as the Comrey district, is fair to fairly good arable land. This area of undulating to gently rolling topography is quite uniform throughout the profile depth and throughout the area. The soil contains considerable fine sand. A few of the lower draws have a fairly high percentage of solonized soils but the area in general is relatively free of the hard subsoil resulting from solonization.

The following profile taken in section 27, tp. 2, range 6, is fairly typical of this Comrey district:

0″-4″—A. Cloddy, fairly firm, brown in color.

4″-12″—Lower A or upper B_1. In this horizon the clods of the above horizon gradually taper into columns. These columns have a horizontal cleavage that break into large prisms. Brown in color.

12″-20″—B_1. Columnar, somewhat similar in structure to the horizon above but slightly lighter in color.

20"-30"—B_2. Cloddy to massive structure. Fairly heavy lime deposition.

There is considerable sand in each of the horizons. The relatively deep profile is at least partly responsible for the fair to fairly good wheat yield obtained in this area.

The 1.1.6 loam east of the above area and adjacent to Lost river is mainly pasture land.

West of the Comrey area, centering in tp. 3, range 7, the profile, in general, is not as deep nor is the soil as dark colored as in Comrey district. The 1.2/0.2/6 areas are quite variable due to more broken topography and the presence of both till and residual sandstone as parent material. The 1.1.6 clay loam areas are low land that are quite badly eroded and appear somewhat alkaline. The 1.5.6 clay loam is a creek flat and contains patches of arable land.

This latter portion of the general area is, where topography does not render it non-arable, at best only poor to fair arable land. Portions are still cultivated, but there is a high percentage of abandoned land. The variability of the area, the relative shallowness of the profile and the brown to light brown color of the surface soil are all detrimental factors affecting its arability. There are individual quarter sections in this area that are more uniform and are fair arable land.

Residual Loams South of Milk River.

Lying south of Milk River, north of the dark brown soil zone line and east from tp. 1, range 13, is a large area of brown soils that slopes to the north. Belly River sandstone is the uppermost parent rock in the east central portion and Milk River sandstone the uppermost parent rock in the western portion. A few glacial erratics are found over the entire area and in many places some till also remains. In general, near to Milk river the till mantle has all been eroded away and bed rock can often be found within the profile depth. The topography is generally gently rolling with a gradual slope from Sweet Grass hills to milk river. Numerous deep erosion coulees cut the area and often render some portions almost inaccessible.

The individual areas have been given the profile designation 2, 2/6, and 6. In general, the difference in percentage of solonized profiles was found to be the main factor necessitating a separation of areas. The light textured area at the extreme east end is possibly the principal exception to the above statement. Although some areas have been given the profile designation (6), indicating a fairly high percentage of solonized soil and although there has been considerable loss of the surface or "A" horizon, the pits left by this differential erosion are now largely grassed over.

Practically all of the area is at present pasture land and in 1939 there was a good growth of native grasses. However, there are areas, principally those with the normal profile (2) in relatively smooth topography that should be fair arable land. In general the arable lands are in the 1.1.2 loams where these areas are accessible and where they are not too near erosion coulees. Near the edge of the deep draws the profile is often shallow and there is little opportunity to store reserve subsoil moisture.

The break between the brown and dark brown soil in the general area is very rapid so that although adjacent to a higher rainfall locality the soils are of an average brown color.

Solonized Glacial Loams South of Manyberries.

Lying southeast by south of Manyberries and centering in tp. 4, range 5, is a group of soils having a fairly high percentage of solonized profiles and formed on glacial till parent material.

These soils, graded mainly 1.2.6 and 1.2.2/6 loam and light loam, are in gently rolling to rolling topography and slope generally to the west. Stones are few to numerous in this area and although the parent sandstone is relatively close to the surface there appears to be some of the till mantle still remaining.

The surface soil is brown to light brown in color and the profile is relatively shallow. The areas of profile (6) are pasture lands supporting a fair to fairly good grass growth. Some cultivation is being carried on in the 1.2.2/6 loam areas, principally in the north half of tp. 4, range 5. Areas where the topography is fairly level and the greater percentage of the soil has a normal profile might be considered poor to fair arable land.

Soil of Lake Pakowki Flats.

It has been stated earlier in this report that Pakowki Lake, the centre of an inland drainage system, is an intermittent lake. During 1939 and for at least seven or eight years previously it has been dry. The present lake bed is, in general, a heavy grey black clay that supports mainly wild barley growth. Two surface samples (0″-8″) from this lake bed were analysed. One contained about 1.4% and the other 0.35% total water soluble non-volatile solids. This is not an extremely high salt content for an inland basin.

Particularly along the east side of the present lake bed, lie extensive flats that were possibly once part of the lake bed but that since the shore line retreated have received deposition from the inflowing streams. There is a considerable depth of this fluviatile material and the deposition process is still in progress. These deposits are an intricate mixture of soil textures ranging from fine sand to clay. The flat is level and is practically stone free.

There is a considerable amount of very fine sand deposited in this flat and most of the mapped light loam areas are principally of this very fine sand. A profile typical of this soil type was taken in section 36, tp. 3, range 7. It gave a massive, somewhat layered, very fine sand to at least 30 inches. The soil is very light colored and has a fairly high lime carbonate content practically to the surface. In places this light textured soil is only a shallow deposition over clay and in other places there is a clay deposition over the very fine sand. A profile taken six miles north of the one described above, namely in section 1, tp. 5, range 7, illustrates this.

0″-15″—A cloddy black clay.
15″-20″—A cloddy sandy clay containing a trace of lime.
26″-36″—Very fine sand containing lime.

In some of the clay areas the light sandy soil occurs more as narrow lenses in the clay deposition.

A large percentage of this flat is flood irrigated during the spring run-off. This water floods some cultivated lands and some land still in its native state. The flooded sod produces a good growth of hay, due partly to the sweet clover and other grasses that have volunteered on this land. With the addition of irrigation water most of this soil seemed fairly productive; however under dry farming conditions the light colored sandy soils might be quite droughty. With adequate storage reservoirs much of this area might be ditch irrigated and thereby better use would be made of the available run-off waters (see plate 7, figs. 1 and 2).

An arm of this fluviatile basin extends up Orion Creek to a point just south of the village of Orion. This portion is quite similar to the area just described excepting that possibly there is, here, more solonized soils.

The sand and sandy loam areas along the north side of the lake are pasture lands. Sand grass is the principal grass particularly on the sand area. Although this is a coarse pasture grass, it is quite effective in preventing the sand dunes from moving.

Along the west shore of the lake are areas of 1.4.2. fine sandy loam. These are mainly shore line deposition and outwash and are non-arable. The 1.5.2. and 1.6.2. fine sandy loams along the west side of the lake are fairly uniform areas and portions of them, particularly the portions in lower topographic positions, are fair arable lands.

The 1.6.2 silty clay loam on the west shore is a fairly heavy textured, level flat. The profile is deep. It is fairly good arable land.

Alluvial Loams to Clay Loams between Manyberries and Ranchville.

Associated with the Manyberries, Orion and Peigan drainage courses and located principally in townships 5 and 6, ranges 5 and 6, and tp. 7, range 5, lie a group of alluvial soils mapped mainly as 1.5.2 and 1.5.2/6. There are a few small areas of 1.5.6 outlined where the percentage of solonization is quite high. These areas are in undulating to gently rolling alluvial basins through which the present coulee draws have cut fairly deep channels. The areas are mainly upper benches that at present receive very little additional deposition material. Immediately east of these basins lie the higher residual lands that slope from the Cypress plateau. Immediately west of these basins lie soils formed from glacial till.

The area just north of Manyberries is quite light colored and has a medium shallow profile. It is from poor to fair arable land.

The 1.1.2/6 clay in tp. 6, range 5, is a deep draw walled in by high residual ridges. The parent shale in this draw has been somewhat sorted and has possibly received some depositions from the surrounding higher land. Excepting where the undisturbed shale comes to the surface the area is fair arable land.

The alluvial (5) areas in tp. 7, range 5, graded loam, heavy loam and clay loam, are quite variable in texture within any one area. This variability ranges from streaks of fine sandy loam to pockets of clay. The major portion of these areas is on an upper bench although there are some bottom lands large enough to be cultivated. The 1.3.2/6 heavy loam is a more uniform area than the alluvial areas on either side. These areas lying adjacent to the dark brown soil sub-zone line, are of a good brown color. A considerable amount of the district is cultivated and in general is fair arable land.

Glacial Loams between Orion and Bullshead.

North of Orion and lying between the alluvial areas described above and the heavy textured basin between ranges 7 and 8, that is principally in townships 6 and 7, ranges 6 and 7, and township 8, range 7, is a group of brown glacial loams and heavy loams. Although there are some areas of solonized soil containing a fairly high percentage of eroded pits, most of the soils in this general area have a normal profile. The glacial till is relatively shallow over most of the area. The topography is gently rolling to rolling, with a general slope to the west and is cut by numerous draws. Stones vary from few to numerous, but in very few places are they a distinct handicap to cultivation.

The soil is a brown color, in general a slightly lighter brown than the soils west of Pakowki lake. The area as a whole is pasture to poor arable land. Only a small percentage of the area is at present cultivated, and there is a considerable number of abandoned parcels. However, some of the more level portions with normal profile are fair arable lands; particularly if these portions are so situated locally that they are able to retain some of the spring run-off waters. Such favorable portions are generally slightly darker in color and have a deeper profile than the surrounding soils.

Heavy Textured Basin West of Bullshead.

Lying in townships 7 and 8 between ranges 7 and 8, is a basin of clay to clay loam soil. It was suggested earlier in this report that this trough-like area may at one time have been part of a northern outlet of Pakowki lake. The area has been mapped as sorted glacial and glacial lacustrine; unsorted glacial till is found on both sides of the basin. Erosion cuts indicate that the lacustrine clay deposition is generally not deep and that a lighter textured material lies relatively close to the surface. Stones are few and the topography is level to undulating.

The 1.7.5 clay at the south end of the area is in general, too heavy and alkaline to be cultivated. The 1.7.6 clay near the centre of the area has a hard columnar subsoil that is difficult to penetrate. The remainder of the area carries the profile designation 2/6. The profile varies from a fairly friable columnar type to the hard round top of the solonetz. The surface horizon depth also varies. In places there is up to eight inches of "A" horizon, in others barely over one inch. The loss of top soil, however, is relatively uniform over a given area, and the patchy micro-relief so characteristic of the solonized areas is not so apparent in this area.

In general the 1.3.2/6 and 1.7.2/6 areas are fair arable land.

Glacial Loams North of Chin and Seven Persons Coulees.

Lying north of Chin and Seven Persons coulees and carrying as far west as the east side of tp. 8, range 12, is a fairly large area of glacial soil mapped principally as 1.2.2 and 1.5/2.2 loam. The topography is mostly undulating to gently rolling. The mantle of glacial till is relatively shallow and is fairly stony.

The profile in this area is not deep, lime generally being found at about 12 inches. The surface horizon is a brown color, generally of a friable cloddy structure; the subsurface or B_1 horizon generally columnar. The 1.5/2.2 area does not differ greatly from the 1.2.2 area; both contain considerable sand and grit, but in the glacial alluvial area there appear to be more gravel lenses in the profile, evidence of post glacial stream action. In a general way the profile gets slightly darker, deeper, and a little more uniform going from east to west. The rainfall gradually increases from east to west and the change to the sorted soils west and north of this glacial area is very gradual.

Soil drifting has occurred in places in this general area. Although not serious at present, the relatively shallow nature of the soil suggests that the loss of any surface soil is quite serious. The area is practically all cultivated and is fair arable land.

The areas of 1.5.2, principally in tp. 7, range 11, are quite variable and within their boundary may be found streaks of quite sandy soil, some of which have drifted quite badly. These sandy streaks should be seeded to grass. In this way they would cease to be a menace to the surrounding arable land. The 1.5.2 light loam in tp. 8, range 9, is similar to the one described above.

The fairly large areas of fine sandy loam and sandy loam in the eastern portion of this general area, are generally too light textured to be considered as arable land. Quite often these areas can be seeded to a permanent grass crop in a favorable climatic year. Once a good catch is obtained, the pasture value, even during the unfavorable years, is fairly good.

Also in this eastern end are some small areas of 1.3.2 (sorted glacial) silt and clay loams. These are relatively level areas of uniform texture and profile. They are fair to fairly good arable land.

Sorted Loams and Silt Loams North of Chin Coulee.

Lying north of Chin Coulee and north and west of the glacial loams described immediately above, is an area of medium textured sorted soil on glacial till. The areas are mapped principally at 1.3.2 and 1.6/2.2 loam and silt loam. Scattered through this general area are some ridges of glacial loam, some fine sandy loam and sandy loam of alluvial deposition, and two areas of glacial lacustrine silt loam, one in tp. 8, ranges 10 and 11, and one in tp. 8, ranges 12 and 13.

This general area lies on the eastern end of the large Lethbridge laking basin. The ground moraine here is relatively shallow and has been sorted by both wind and water. Stones are generally few and topography is mostly undulating.

In the northwest corner of the sheet, mainly in tp. 8, range 15, is an area of 1.3.2 silt loam. This is a medium textured soil with a fairly deep profile and from brown to dark brown in color. The area is practically all cultivated and is fairly good to good arable land. Lying immediately south of this is an area of heavy loam that is a mixture of sorted and unsorted glacial till. It is part of a transition area between the sorted silt loams to the north and the large glacial loams and clay loams area south of Chin Coulee. It is somewhat variable and has some stones. It is fair to fairly good arable land.

On the eastern side of this general area and adjacent to Fortymile coulee, is an area of 1.7/2.2 silt loam. This is a medium to heavy textured silt loam, uniform and practically stone free. It is good arable land. Adjacent to the above area, and to the southeast, is an area of 1.3.2 loam that is undulating to gently rolling, composed of long low sweeps. The soil is somewhat gritty and there are a few stones. The area is fairly uniform, however, and is generally fair to fairly good arable land.

Lying between the above described 1.3.2 loam of tp. 8, range 10, and the 1.3.2 silt loam of tp. 8, range 15, is a large undulating to gently rolling area mapped principally at 1.6/2.2 loam and light silt loam. The areas are fairly uniform and have very few stones. The profile averages about twenty inches to the B_2 or lime horizon and can, therefore, be considered as fairly deep. The texture varies from very fine sandy loam to light silt loam. The presence of a high percentage of very fine sand is characteristic of the area. It is thought that post-glacial winds have been responsible for much of the sorting and for some deposition in the area. Unless care is exercised, soil drifting could easily become a problem in these soil types.

The following profile taken in section 22, tp. 8, range 13, is typical of the 1.6/2.2 areas of this group.

0″-6″—A. Brown, cloddy but friable.

6″-17″—B_1. Brown, prismatic to columnar structure that readily breaks into small elongated clods that widen towards the base. There is very little evidence of deposition stains in the horizon.

17″-30″—B_2. Structureless to massive, easily crushed, contains a fairly high lime deposition. Much of this area is cultivated and in general, it is fairly good arable land.

Scattered throughout this general area is a fairly large acreage of alluvial fine sandy loam. These areas are associated with stream courses and post-glacial lake shore lines. Soils of this type in the brown soil zone are inclined to be droughty and subject to drifting and are generally poor arable lands.

The sandy loam area adjacent to Chin Coulee is possibly of alluvial origin but has subsequently been moved by wind and now, in places, is piled into dunes. It is pasture land.

Glacial Heavy Loams and Clay Loams Along Etzikom Coulee.

Within a triangle having its base the west side of tps. 5, 6, and 7, range 15, and its apex the southwest portion of tp. 4, range 7, lies a large area of fairly heavy glacial soils, mapped mainly a 1.2.2 heavy loam and clay loam. In general there is very little difference in texture between the heavy loam and clay loam areas. This is a glacial morainal area. The area is undulating to rolling and in general could be classed as gently rolling. The hills are low and those portions that are mapped as rolling are generally the more choppy type of topography. The area is stony; the ridges being particularly so. The following profile taken in section 22, tp. 5, range 14, is fairly typical of the area.

0″-3″—A. Friable, somewhat cloddy. Brown to dark brown. No clear division between this horizon and the one below.

3″-10″—B_1. Prismatic to columnar. Columns narrow at top but widening to more prismatic structure near the bottom of the horizon. A little deposition staining near to top. Brown. (In most of the area the B_1 horizon is more granular than in this profile) (see plate 6, fig. 2).

10″-16″—B_2. This is the cloddy ends of the B_1 columns. Fairly hard. Contains lime.

at 20″ C.—Hard, massive to structureless. Contains lime deposition as well as lime spots, also some red flecks.

There are stones in this profile.

In general, the lime deposition horizon is nearer to the surface in this area than in the slightly lighter textured sorted areas to the north and to the south. Although there are patches of cultivation scattered all through the area, there are still large blocks uncultivated and used as pasture. The more uniform areas on undulating to gently rolling topography are fair to fairly good arable land. The rougher and more stony areas are better left as pasture lands. Excluding Etzikom coulee and Kings lake, there are few watering places in the area and relatively few good sites for coulee dams.

Connected with the above described area by a strip of 1.2.2 clay loam along the north bank of Etzikom Coulee south of Foremost and Nemiscam is a fairly large area of 1.2.2 heavy loam and clay loam adjacent to the village of Etzikom. It centres in tp. 6, range 9, and tp. 7, range 8; although a small area lies south of Etzikom coulee principally in tp. 5, ranges 9 and 10. This area has considerable rolling land and some portions, particularly north of Etzikom, are very stony. The profile is shallow and slightly lighter in color than the larger area described above. In general, it is pasture land although some of the leveller portions have been cleared of stone and now may be considered poor to fair arable land.

Sorted Heavy Loams and Silt Loams South of Chin Coulee.

Lying immediately south of Chin Coulee between Skiff and Nemiscam is an an area of sorted soil on glacial till with level to undulating topography, and mapped as 1.3.2 and 1.6/2.2 loams and silt loams. In general these soils are silty, quite uniform and relatively stone free. The profile is fairly deep and quite friable. A profile dug in section 19, tp. 6, range 13, had 4 inches of wide columnar brown A, 8 inches of friable dark brown B_1, and at 12 inches the B_2 lime horizon. This is quite typical of the 1.3.2 heavy loam area. It is practically all cultivated and is fairly good to good arable land. In a narrow strip along the edge of the coulee lies an area of 1.3.2 loam. This area contains a little more grit than the heavy loam to the south and is subject to a little erosion into the coulees. It is fair to fairly good arable land.

The area adjacent to Foremost is graded a 1.6/2.2 silt loam. This is a very uniform, practically stone free area of medium to light silt loam texture. The following profile was taken in section 18, tp. 6, range 11.

0″-10″—A. Brown, cloddy, friable.

10″-22″—B_1. Brown, prismatic to columnar. There are some deposition stains and the horizon, in general, is a little more compact than the one above.

22″-34″—B_2 and upper C. Wide columnar. There is a little lime deposition and also some lime streaks.

This area is fairly good to good arable land.

The area of 1.6/2.2 heavy loam between Foremost and Nemiscam, is quite similar to the 1.6/2.2 silt loam just described. Both are deposition areas and possibly are both associated with the large glacial eolian deposition north of Chin Coulee. They have, however, been grouped with the area south of Chin coulee rather than with the eolian area north of Chin coulee because they are similar in utilization to the sorted loams lying immediately west (see plate 8, fig. 1).

Included in this general area are the sorted glacial loams and heavy loams south of Etzikom coulee, principally in tp. 5, ranges 9 and 10. These soils are from loam to silt loam in texture, have a fairly friable and a relatively stone free profile. The lime horizon is found from 12 to 18 inches below the surface. The A or surface horizon, like much of the larger general area described above, is a fairly dark phase of brown soil. The topography is strongly undulating and the area is therefore not as uniform as the ones immediately south of Chin coulee. It is fairly good arable land.

Mixed Loams between Allerton and Lucky Strike.

Lying between the glacial clay loam area south of Etzikom coulee and Milk river, principally in townships 12 and 13, is a general area of loam soils that are fairly closely associated with the underlying bed rock. They have been mapped principally at 1.1.2/6 and 1.2/0.2/6 with a few areas of normal (2) profile and a few that have a high enough percentage of solonized soils to be mapped as profile (6). Although some glacial material still remains, particularly in the higher ridges, bed rock exposures are common in the area. The soil areas all contain solonized soils in varying degrees and in places where the bed rock comes practically to the surface there is considerable differential erosion.

The topography of the area is mainly undulating to gently rolling, generally in the nature of long gentle sweeps from the ridges ending in many wide valleys of sorted soils. Stones, excepting in the ridges, are not a deterrent to cultivation. In general the areas that have only a small percentage of solonized profiles mapped as 2 or 2/6, are fair to fairly good arable land. The badly solonized areas and some of the rougher areas are from fair pasture to poor arable land.

Included in this general area is an area of 1.1.2 loam centering at Masinasin. It is level to undulating and relatively stone free. Although the parent rock is quote close to the surface there appears to have been some water sorting and some deposition over the area. A profile dug in this area was of a prismatic structure with the lime horizon at 16 inches. It is fair to fairly good arable land.

At present from 25 to 50% of the area is cultivated. The abandoned land, lying principally south of Lucky Strike, has in the main been deserted since 1920 to 1925 and at present supports some grass growth.

Glacial and Sorted Glacial Loams of the Southwest Corner.

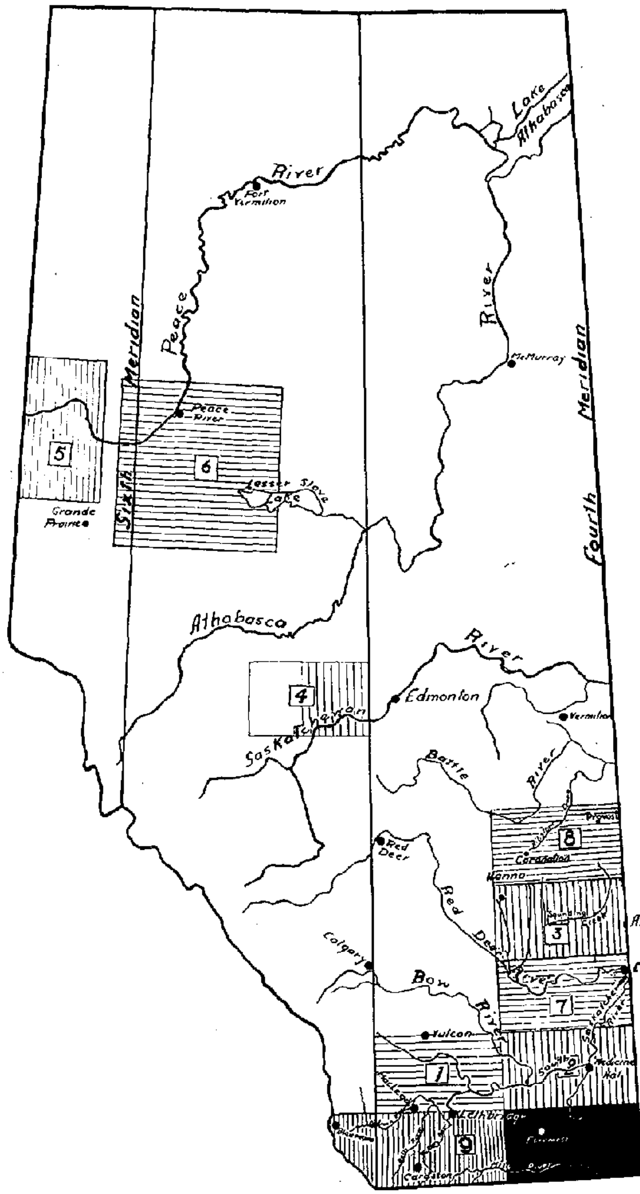
Lying principally in townships 1, 2 and 3, ranges 14 and 15, is a group of sorted areas from loam to clay loam in texture and formed in a relatively shallow glacial till that is partly sorted and partly unsorted. The topography is undulating to gently rolling. Stones are fairly numerous in the unsorted till but relatively few in the more uniform sorted areas. Although they are mainly graded a 1.3.2 or 1.2.2, patches of solonized soils occur, principally in the lower portions of the areas. There is also the occasional pit where the surface horizon has been eroded off.

The profile is generally of a wide columnar structure and the lime horizon varies from 10 to 20 inches from the surface. In general the greater depth is found in the more sorted portions.

The area in general is about two-thirds cultivated and there is practically no abandoned land. In general it is fair to fairly good arable land.

The area of fine sandy loam in townships 1 and 2, range 15, is pasture land at present and should remain so. It has been very closely grazed so there is little reserve grass cover.

PLATE 1



Sketch map of Alberta showing locations of surveyed areas for which reports have been published. (1) Macleod sheet; (2) Medicine Hat sheet; (3) Sounding Creek sheet; (4) St. Ann sheet; (5) Dunvegan area; (6) Peace River-High Prairie-Sturgeon Lake area; (7) Rainy Hills sheet; (8) Sullivan Lake sheet; (9) Lethbridge and Pincher Creek sheets; (10) Milk River sheet.

PLATE 2

Fig. 1—Milk River sandstone is the uppermost bed rock in the southwest corner of the sheet. In general it is covered by a shallow till.

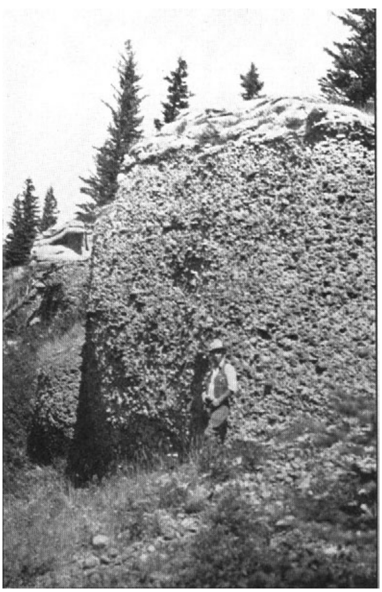


Fig. 2—Cypress conglomerate. At least 50 feet of this cemented gravel underlies the plateau shown in Fig 1, Plate 3.

Fig. 3—Artesian well. These wells (500 to 1,000 feet deep) are fed from an artesian basin that centers in this sheet.

PLATE 3

Fig. 1—Level unglaciated top of Cypress hills. Scrubby cinquefoil is common in this black soil. The underlying conglomerate is from 2 to 4 feet below the surface.

Fig. 2—Cypress Hills forest reserve. This area is valuable as a source of timber as well as a playground. Note the leached soil profile.

Fig. 3—An arable valley in the Cypress Hills. The slopes are good pasture.

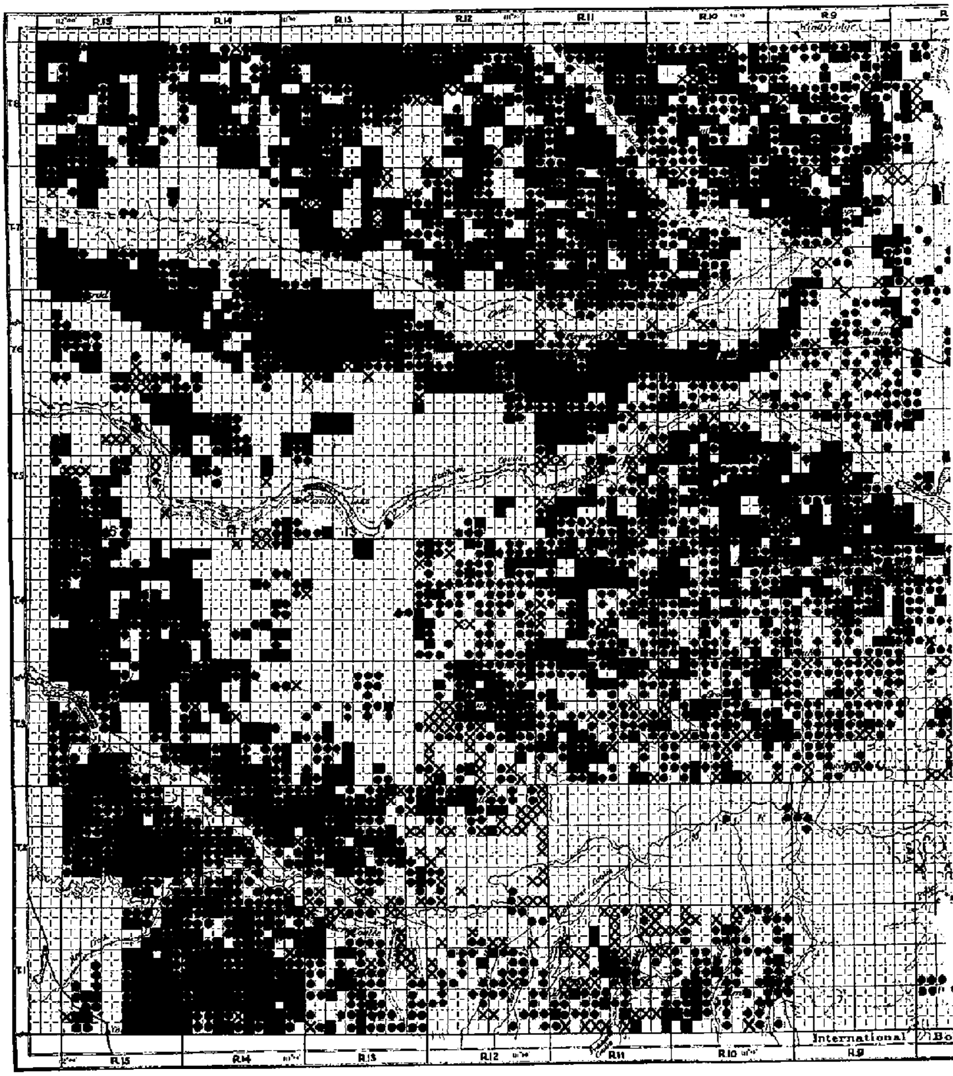
PLATE 4

Fig. 1—Exposed Bearpaw shale east of Manyberries. This bed rock formation forms the surface mantle in much of the east portion of the sheet.

Fig. 2—The area south and east of Manyberries is practically all range land. Note the bare spots, in the middle foreground, characteristic of this area of solonized soil.

Fig. 3—Belly River sandstones on Chin Coulee. This coulee is one of three old drainage ways found on this sheet. A shallow mantle of glacial till covers most of the Belly River rock.

Present Cultivated, Abandoned anc



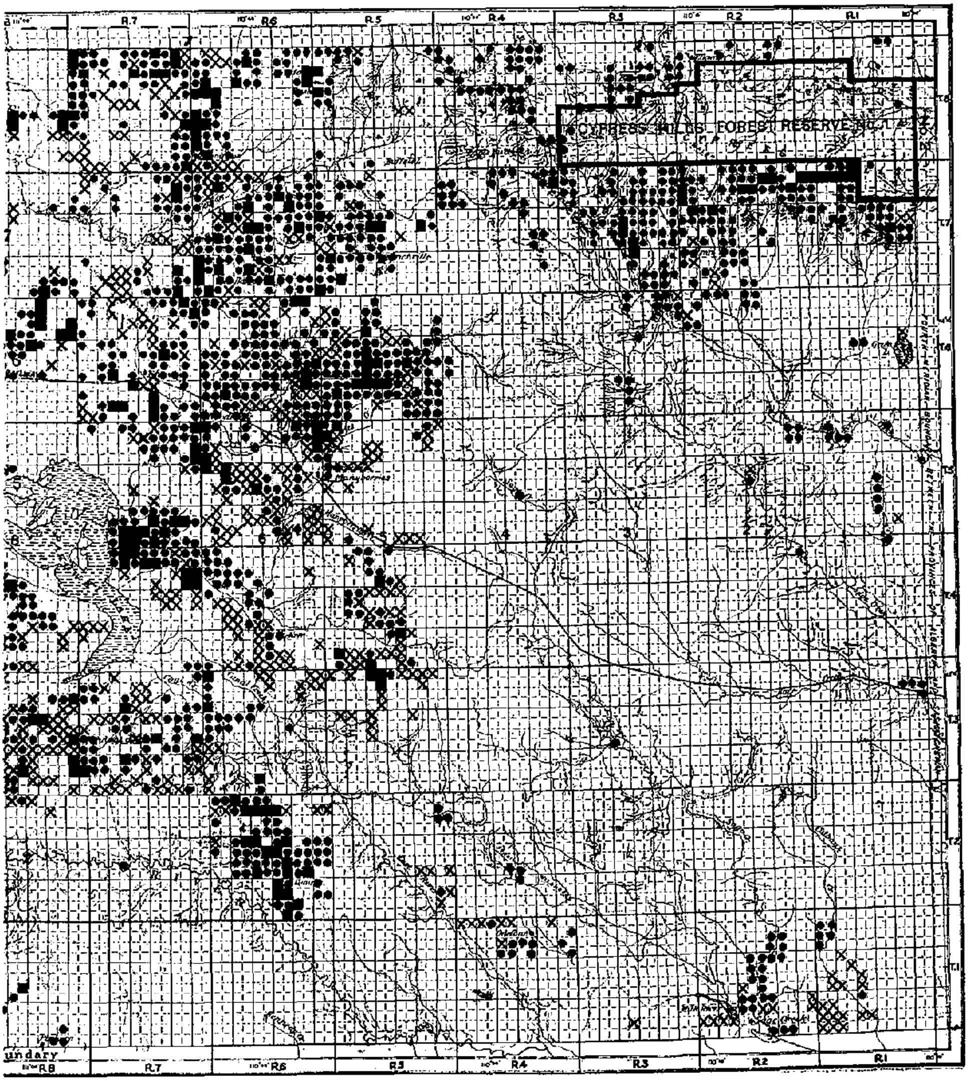
LEC

Completely Cultivated (140-160 acres)..................... ■

Partially Cultivated (10-140 acres).............................. ●

TE 5

l Virgin Lands of Milk River Sheet



GEND

Abandoned Cultivation (10-160 acres) .... ☒
Virgin Lands (Idle and Pasture) .... ☐

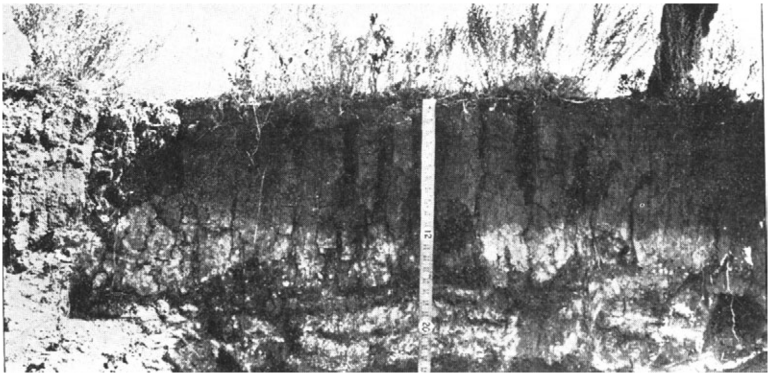


Fig. 1—1.2.2 loam north of Manyberries. Note the wide columns and also the closeness of the lime horizon to the surface. Sage is a common plant in this area.

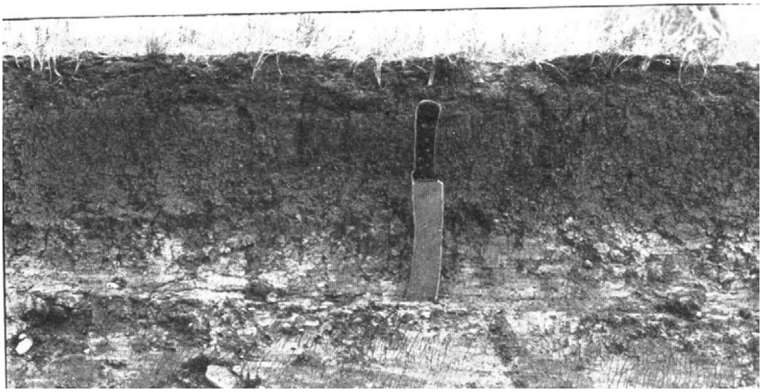


Fig. 2—1.2.2 clay loam south of Foremost. Note the somewhat granular structure, also what might be a little eolian deposition over the glacial till.

Fig. 3—2.2.2 loam near Sweet Grass hills. An island of dark brown soil lies adjacent to this elevation. Note the fairly heavy grass growth.

PLATE 7

Fig. 1—The level bed of old Lake Pakowki. These soils have remained quite productive under a flood irrigation system.

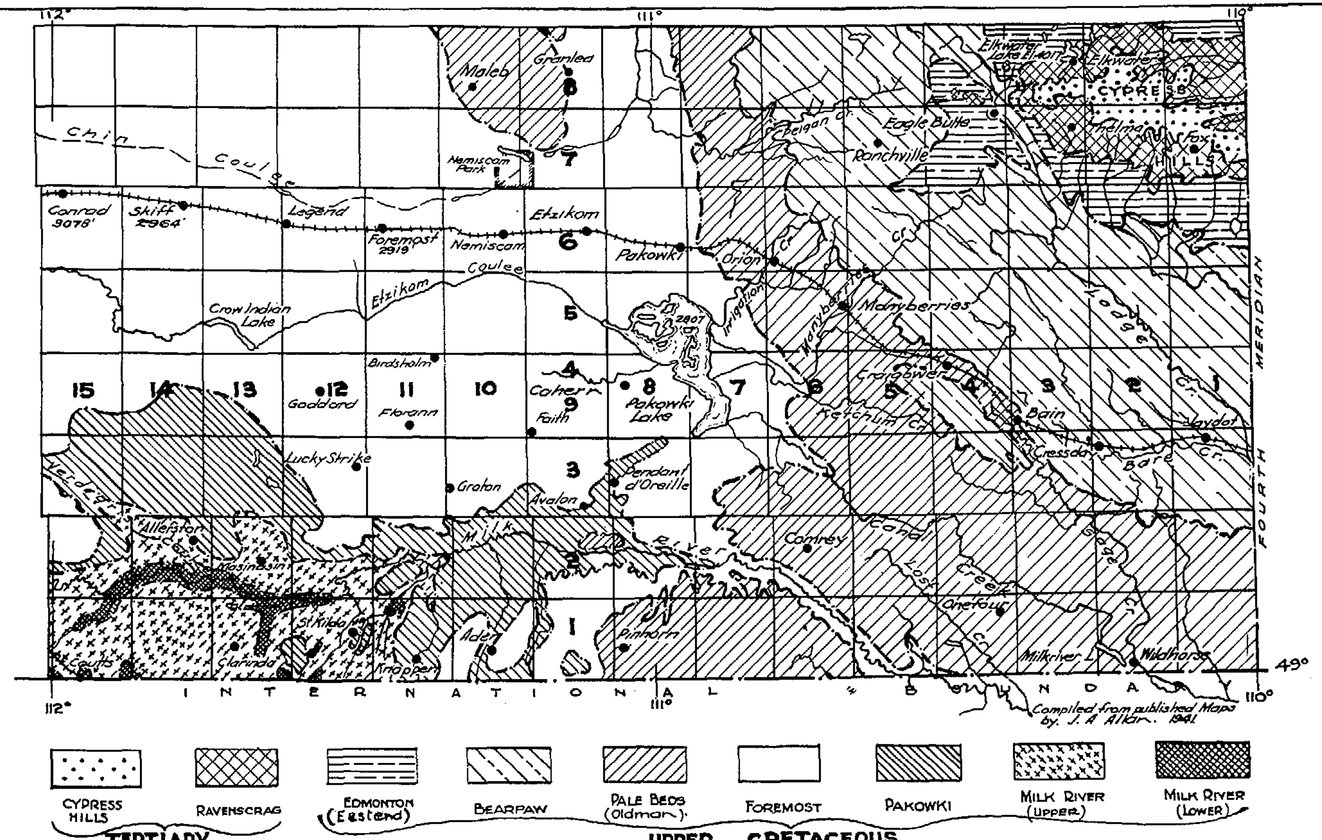
Fig. 2—An irrigation dyke on the Orion flat. These spread the spring run-off water. A ditch system would make a more economical use of available water.

Fig. 3—Typical of Milk River valley from Range 8 to Range 13. Alluvial fans that offer possibilities for irrigation are found in this valley.

Fig. 1—Combining wheat on a sorted glacial area west of Foremost. The large stretches of this fairly uniform brown soil are adaptable to power farming.

Fig. 2—Dam listing with the one way disc to hold the spring run-off. Experiments to find the most desirable methods of run-off conservation are still in progress.

Fig. 3—Alfalfa in rows in the brown loams of the Comrey district. A legume adds much needed nitrogen and fibre to a soil that has been under a continuous wheat fallow rotation.



GEOLOGY OF THE MILK RIVER SHEET

0 5 10 20 30

Scale of Miles

TABLE VI.—SOIL AREAS OF BROWN SOIL ZONE

Series	Location	Topography	Total Acres	Classification	REMARKS
SAND:					
1.0.0	2-12	U.	300	F.P.	Edge of river.
1.5.0	3-6	U.	700	F.-F.G.P.	Variable area, some dunes.
1.6.0	4-6 & 5-7	G.R.-R.	9000	F.P.	Dune area.
SANDY LOAM:					
1.0.0	1-4	G.R.	700	F.P.	Edge of coulee
1.5.0	7-9 to 8-8	G.R.	2600	F.P.	Some dunes, subsoil generally heavy.
	8-8, 6-9				
	3 & 5-13, 7-14	U.-R.	5600	F.P.	Associated with drainage courses. Often coarse sand.
1.6.0	1-1 & 2	U.	4500	F.P.	Coarse sand, some shore lines.
	5-7 to 6-8	G.R.	7000	F.P.	Some dunes and sloughs.
	7-14	L.-U.	3600	F.G.P.	Texture variable.
FINE SANDY LOAM:					
1.0.2	1-4 & 5	L. & G.R.	25000	F.G.P.	On parent sandstone, some stones in G.R.
1.0.2/6	1-6	G.R. to H.	13000	F.-F.G.P.	Few stones, sandstone exposures.
1.1.2	2-11	G.R.	4000	F.-F.G.P.	Profile fairly deep. Numerous stones.
1.1.6	1-3 to 2-4	G.R.	3500	F.-F.G.P.	Very few stones. Generally 6-8″ of A horizon.
	5-5	G.R.	800	F.P.	Few stones and gravel, washed.
	3-6	U.-R.	1500	F.P.	A slope to the creek.
1.2/0.2	1-2 to 1-5	G.R. & H.	6000	F.-F.G.P.	Numerous stones, glacial till on knolls.
1.2/0.6	1-5	G.R.	800	F.P.	Partly eroded.
1.2.2	5-13 & 14	G.R.	500	F.P.	Numerous stones edge of coulee.
	1-15	U.	2000	Pr.-F.A.	Few stones. Texture F.S.L. to Lt.L.
1.2.6	3-5	R.	1000	F.P.	
1.3.6	5-6 & 7	U.-G.R.	1200	Pr.-A.	Solonization not extensive.
1.4.2	4 & 5-8	U.-G.R.	8000	F.-F.G.P.	Portions quite stony.
	7-15	G.R.	300	F.-F.G.P.	
1.5.0	2-11 & 2-12	U.	600	F.-F.G.P.	Milk River flood plains.
1.5.2	1-1 to 1-4	U.-G.R.	12000	F.-F.G.R.	A little solonization in patches.
	5-8	U.	2200	F.-F.G.R.	Islands in Pakowki lake.
	4-8 & 5-9	U. & G.R.	2700	Pr. & F.A.	Variable texture and some gravel.
	7-9	U.-G.R.	2000	F.G.P.-Pr.A.	Few stones and some gravel.
1.5.2	8-9	G.R.	300	F.P.	This is a ridge.
	2-11	G.R.	500	F.G.P.	Old river bed.
	7 & 8-12	U.	2000	F.-F.G.P.	Streaked with sand.
	7-13 & 14	L.-U.	1500	F.G.P.-Pr.A.	No stones, deep profile.
	8-14 & 7-15	G.R.	2500	Pr.-A.	Coarse sand, a little soil drifting.
	5-14	G.R.	500	F.P.	Along coulee banks.
	1 & 2-15	U.-G.R.	3300	F.P.-P.A.	Very sandy towards the northeast.
	2-15	U.	1000	Pr.-F.A.	Low land, very few stones.

TABLE VI.—Continued

Series	Location	Topography	Total Acres	Classification	REMARKS
1.5.2/6	1-1 to 1-4	U. & G.R.	9000	F.P.	Solonization in lower portions, very few stones.
1.5.5	7 & 8-8	L.	800	F.P.	A river flat, washed.
1.5.6	1 & 2-4	U.-G.R.	2000	F.-F.G.P.	
1.6.2	6-7 & 4-8	G.R.	1500	Pr.-F.A.	Very few stones.
	8-12	L.-U.	5000	F.G.P.-Pr.A.	Very few stones, some soil drifting.
LIGHT LOAM:					
1.1.2	1-6	U.	600	Pr.-F.A.	Very few stones.
	2-11 & 12	U.-G.R.	1000	F.G.P.	Shallow profile. Variable texture.
1.1.2/6	2-5	G.R.	8000	F.-F.G.P.	Some stones. Many small sloughs.
1.1.6	1-2 to 2-5	G.R.	40000	F.-F.G.P.	Stony. 30% to 50% surface eroded off; A horizon light textured.
	1-5 & 1-7	G.R. & R.	10000	F.-F G.P.	30% surface eroded off.
1.2/0.2	2-2	G.R.	1000	F.-F.G.R.	Stony; edge of creek.
	2-13	G.R.-R.	2000	F.-F.G.P.	Sandy spots and a little solonization.
1.2/0.2/6	3-6	R.	2000	F.-F.G.P.	Badly cut by erosion coulees.
	2-1 to 4-6				
	4-1 to 4-3	G.R.	115000	F.-F.G.P.	Stony; 30% to 50% surface eroded off, often grassed over.
1.2.2	1-15	G.R.	1100	F.-F.G.P.	Numerous stones, slopes to creek.
1.2.6	4-6	G.R.	6000	F.-F.G.P.	20% surface eroded off; some abandoned land.
1.5/2.2	7-12	L.-U.	1200	F.A.	Variable texture and deposition.
1.3.6	5-6	G.R.	3500	F.-F.G.P.	Few stones; 25% surface eroded off.
1.5.0	7-14	L.-U.	400	G.P.-F.A.	Coulee bottom.
1.5.0/7	3-6, 4-7	L.	3000	Pr.-F.A.	Spring flooded. V.F. sand deposition.
1.5.2	4-8, 8-9	G.R.	3500	Pr.-F.A.	Partly cultivated, variable texture.
	6-9	U.	1200	F.A.	Basin area. Fairly uniform.
	3-12	L.-U.	500	F.P.-Pr.A.	A draw, part marshy.
1.5.6	1-2 & 3	U.-G.R.	10000	F.-F.G.P.	Few stones; 25% to 50% surface eroded off.
	5-6	U.-G.R.	1700	P.-F.P.	50% to 75% surface eroded off.
1.6.2/6	2-7	L.-U.	300	F.P.-Pr.A.	An alluvial flood plain.
1.6.6	5-6	U.	4000	F.P.	Very few stones; 30% to 40% surface eroded off.
LOAM:					
1.0.1	5 & 6-4	H.	5000	F.G.P.	Stony.
1.0.2 (St.)	6 & 7-1	U.-R.	2600	F.-F.G.P.	Very stony; cut by draws.
1.1.2	1-6, 2-7	G.R.	2000	Pr.-F.A.	Few stones.
	2-8	G.R.	4000	G.P.-F.A.	Fairly deep profile cut by erosion.
	2-10 to 3-11	U.-G.R.	22000	F.A.	Few stones. Profile fairly deep.
	2-13	L.-U.	2500	F.-F.G.A.	Very few stones.
1.1.2/6	4 & 5-4	G.R.	4000	F.-F.G.P.	Some stones. Erosion pits grassed.
	2-6	G.R.	9000	F.A.	Very few stones; brown to dark brown color.
	1-7 to 2-8	G.R.-R.	14000	G.P.-F.A.	Badly cut by erosion draws.
	2-12	U.	10000	F.A.	Fairly deep profile. Very few stones.
	2-10	U.	1000	G.P.-Pr.A.	

1.1.6	1-8, 2-8	G.R.	2500	F.G.P.	Few stones; 10% to 25% surface eroded off.
	3-7, 3-8	U.	5000	F.P.-Pr.A.	Variable texture, few stones.
	2-10, 2-11	L.-U.	1000	F.G.P.	These are lower areas.
	2-5, 5-5	U.-G.R.	17000	F.-F.G.P.	Numerous stones; 25% to 50% surface eroded off.
	1-7	R.-H.	2500	F.G.P.	Not badly solonized.
	2 & 3-12	G.-R.	2000	F.G.P.	50% surface eroded off.
1.2/0.2	1-11 to 2-13	U.-R.	26000	F.P.-F.A.	Shallow profile; some stones; cut by coulees.
	1-8, 3-12	G.R.-R.	12000	Pr.-F.A.	Fairly deep profile.
	6-4, 1-4	R.-H.	12000	F.-G.P.	Stony.
1.2/0.2/6	2-1 to 2-2 & 4-2 to 6-5	G.R.-H.	56000	F.-F.G.P.	Stony; profile fairly shallow.
	3-6	G.R.	6000	F.G.P.-Pr.A.	Some stones.
	2 & 3-7	R.	600	F.-F.G.P.	Crown, slopes to creek.
	2 & 3-11, 2-13 & 14	G.R.	5500	F.A.	Few stones; fairly deep profile.
	1-9, 1-10	G.R.-R.	6500	F.G.P.-F.A.	Texture somewhat silty, cut by erosion.
	1-12	G.R.	1500	Pr.A.	Numerous stones; slopes to river.
1.2/0.6	2-8, 1-9	U.-H.	26000	F.G.-G.P.	20% to 25% surface eroded off; cut by sloughs and coulees.
	1-1, 3-2 to 4-3	G.R.	30000	F.-F.G.P.	20% to 40% surface eroded off; stony.
	2-6	G.R.	1600	F.G.P.-Pr.A.	Stones; some sloughs.
1.2.2	7-7 to 8-8	U.-R.	27000	F.G.P.-P.A.	Numerous stones; general slope to coulee.
	5-7 to 7-6	G.R.-R.	25000	F.G.P.-F.A.	Numerous stones, occasional solonized patches.
	8-8	G.R.-R.	7000	F.G.P.-Pr.A.	Gritty texture.
	2 & 3-8	U.-R.	8000	F.P.-F.A.	Some stones.
	5-9 & 10	U.-G.R.	5000	F.A.	Few stones.
	5 & 7-13, 5-15	U.	6000	F.-F.G.P.	Quite stony, areas are along edges of erosion coulees.
1.2.2	4 & 5-13	U.-R.	6000	F.G.P.-F.A.	Some stones; variable texture.
	8 & 9-10, 2-14	G.R.	25000	F.A.	Few stones; fairly deep profile.
	7-10 to 7-12	G.R.	40000	F.-F.G.A.	Some stones.
	3-10 to 3-12	G.R.-R.	25000	G.P.-F.A.	Numerous stones; variable depth of profile.
	1 to 3-15	G.R.	8000	Pr.-F.G.A.	Some stones; stony profile.
1.2.2 (Gv.)	6-7	G.R.-R.	1800	F.P.	
1.2.2/6	3 & 4-5	G.R.-R.	8500	F.G.P.-M.A.	Relatively high land.
	3 & 4-5	G.R.-R.	4000	F.-F.G.P.	
	5 & 6-6	G.R.	20000	Pr.-F.A.	Numerous stones.
1.2.6	3 & 4-5, 6-6	G.R.-R.	12000	F.-F.G.P.	Some stones; 25% to 50% surface eroded off.
	3-11, 5-8 & 9	U.	1500	F.G.P.	Low areas.
1.5/2.2	7 & 8-9	U.-G.R.	12000	F.A.	Few stones; variable texture, much fine sand.
	8-11 to 8-13	L.-U.	12000	F.A.	Deep profile; little soil drifting.
1.6/2.2	8-12 to 8-14	L.-G.R.	15000	F.-F.G.A.	Very few stones; deep profile.
1.3.2	6 & 7 & 8-7, 7-8	U.	4200	F.A.	Very few stones; texture somewhat silty.
	7 & 8-10	U.	20000	F.-F.G.A.	Few stones; occasional sand and gravel lense.
	5-9 & 10	U.-G.R.	6000	F.-F.G.A.	Some stones; profile of variable depths.
	3-12, 6-13	L.-U.	9000	F.G.A.	Few stones; deep profile.
	5 & 8-15, 7-13	U.	4000	F.-F.G.A.	Some stones.
	2-14 & 15	U.	4000	F.A.	Some stones; relatively shallow profile.
1.3.2/6	7-7	U.	500	Pr.A.	Variable textured draw.

TABLE VI.—Continued

Series	Location	Topography	Total Acres	Classification	REMARKS
	7-7	U.	1500	F.A.	Deep profile; few stones.
	2 & 5-15	U.-G.R.	1800	Pr.-F.A.	5% to 20% surface eroded off.
1.3.6	7-7	U.	500	F.-F.G.P.	Slope to creek.
	7 & 8-10	U.-G.R.	1500	Pr.A.	Semi basin; 10% to 25% surface eroded off.
1.4.0	5-9, 5-10	L.-U.	1000	F.P.	Very stony coulee flats.
1.4.2	7-13	G.R.	300	F.-F.G.P.	Quite gravelly.
1.5.0	5-13	L.	100	F.A.	A coulee flat.
	2-10	L.-U.	2000	Pr.A.	River bottom; very fine sand.
1.5.2	1-1	G.R.	200	F.-F.G.P.	Edge of laking basin.
	5-5 to 6-6	U.-G.R.	8000	F.G.P.-F.A.	Some stones.
	5-8 & 9, 7 & 8-11	U.	8000	F.A.	Few stones; some soil drifting.
	5-9, 2-10	U.-G.R.	1000	F.A.	Upper benches, a little gravel.
	7-11	U.	2600	Pr.-F.A.	Some light textured streaks; portions drifted.
	1 & 2-13	L.-U.	2000	Pr.-F.A.	Few stones; relatively high crown.
	7 & 8-14	U.-G.R.	5000	Pr.-F.A.	Few stones.
1.5.2/6	5-6	L.-U.	600	FG..P.-Pr.A.	Upper bench.
	7-5	U.	800	Pr.-F.A.	Alluvial flat.
	4-6	G.R.	700	F.-F.G.P.	Some stones; edge of alluvial flat.
	3-12	G.R.	2000	F.P.-Pr.A.	Some low and some sloping land.
1.5.5	2-12	U.	400	F.G.P.	Coulee draw.
1.5.6	2-1 & 1-3	U.	2000	F.P.	Variable solonization; patches to 50%.
	5-6, 6-6	U.-G.R.	1600	F.P.	Numerous eroded pits.
	4 & 5-5	U.-G.R.	1000	F.-F.G.P.	Some stones.
	4-6 & 7	U.-G.R.	3500	F.-F.G.P.	Numerous eroded pits.
	4 & 5-8	G.R.	1000	F.P.	Sloping sides of a drain.
	2-12 & 13	U.-G.R.	1500	F.G.P.-Pr.A.	Few stones; variable.
	8-15	L.	100	Pr.-F.A.	15% surface eroded off.
1.6.6	5-6 to 6-7	U.	5000	Pr.A.	Washed surface, area partly irrigated.
HEAVY LOAM:					
1.0.1	5-6, 7-4	H.	5000	F.G.P.	High residual ridge.
1.0.6	5-3, 4-5	G.R.-R.	7500	F.-F.G.P.	Stony; heavy subsoil close to surface.
1.1.2	3-7 & 8	U.	1500	F.A.	Few stones.
	1-13	U.	600	Pr.A.	Very few stones; cut by erosion.
	2-13	L.-U.	3500	F.-F.G.A.	Very few stones; may have some alluvial deposition.
1.1.2/6	3-7, 2-9	U.	3600	F.G.P.-F.A.	Some stones; shallow profile.
	2-12 & 13	U.-G.R.	2500	F.A.	Very few stones; variable profile.
1.1.6	6-1	G.R.	2500	F.G.-G.P.	Some badly eroded pits.
	5 & 6-2	U.-H.	4500	F.-F.G.P.	Cut by erosion.
	3-6 & 7	G.R.	1000	F.P.-Pr.A.	A high crown; solonization; patchy.
	1-12	G.R.	2000	F.G.P.	Cut by erosion; stony.
	3-13	U.	6000	F.G.P.-Pr.A.	Very few stones; profile depth variable.

1.2/0.1	7-4 & 5	H.	3000	F.G.P.	Numerous stones; lower than residual ridge.
1.2/0.2	5-1	H.	4000	F.P.	Very stony; shallow profile.
	5 & 6-3	G.R.-R.	1500	F.G.P.	Crown of higher land.
	3-7, 2-10	U. & G.R.	3000	F.A.	Very few stones; sloping areas.
	1-12	G.R.-R.	1600	F.G.P.-Pr.A.	Some stones; shallow profile near erosion.
	1-13	U.-G.R.	7500	F.A.	Some stones.
1.2/0.2/6	2 & 5-1, 3-3	G.R.	21000	F.-F.G.P.	Some stones; erosion pits mostly grassed over.
	7-5	R.	5000	F.G.-G.P.	
	2-7 to 3-8	G.R.-R.	20000	F.P.-F.A.	Some stones; variable.
	2-9	G.R.-H.	5500	F.G.P.	Numerous stones; a river bank.
	1-14, 3-13	U.-G.R.	1500	F.A.	Few stones; 10% surface eroded off.
1.2/0.6	3 & 4-4	U.-G.R.	3000	F.P.	Numerous stones; some badly washed patches.
1.2.1	3-8	G.R.	2000	Pr.A.	Some stones; edge of coulee.
1.2.2	1 & 2-2	R.	100	F.G.P.	
	7-7 to 6-9	G.R.-H.	42000	F.P.-F.A.	Stony; only few uniform areas arable.
1.2.2	8-8	G.R.-R.	1000	F.G.P.	Stony.
	3-9 to 5-10	G.R.-R.	60000	Pr.-F.G.A.	Some stones; L. to C.L. texture.
	5-9 & 10, 5-11	U.-G.R.	10000	F.A.	Some stones; near erosion.
	7-6	G.R.	2000	Pr.-F.A.	Some stones.
	6-10 & 11	G.R.	800	Pr.-A.	Some stones; slopes to coulee.
	4-11 & 12	G.R.	5000	F.A.	Some stones; relatively shallow profile.
	6-12 & 13	G.R.	7500	G.P.-F.A.	Stony.
	7-13, 8-14	U.-G.R.	4500	F.A.	Few stones.
	6-16 to 8-15	U.-G.R.	50000	F.-F.G.A.	Some stones; portions silty.
	4-14 to 6-15	U.-R.	55000	G.P.-F.A.	Numerous stones; variable profile depth.
	3 & 4-13	G.R.	3500	F.-F.G.P.	Stony shallow profile.
	1 & 2-14 & 15	U.-R.	40000	F.A.	Few stones, some gravel.
	3-14 & 15	G.R.-R.	10000	F.A.	Some stones; fairly deep profile edge of coulee.
1.2.2/6	5 & 6-1	U.-R.	1500	F.-F.G.P.	Very stony.
	8-8 & 9	G.R.	3500	F.A.	Some stones.
	3 & 4-13 & 14	G.R.	15000	F.G.P.-F.A.	Some stones; some shallow profile.
	7 & 8-15	U.	800	Pr.-F.A.	Few stones; marshes.
1.2.6	6-11	U.	300	Pr.-A.	
1.5/2.2	7 & 8-14	U.-G.R.	2100	F.-F.G.A.	Some gravel and sand streaks.
1.6/2.2	6-10	L.-U.	6000	F.G.A.	Very few stones; deep profile.
1.3.2	7-6, 7-7	U.-G.R.	4000	F.A.	Few stones.
	4-9, 5 & 6-10, 5-11	U.-G.R.	20000	F.G.A.	Deep profile; somewhat silty.
	6-11 to 7-14	U.	30000	F.G.A.	Few stones; deep stone free profile.
	8-9, 1-13, 5-13	U.	4000	F.-F.G.A.	Few stones.
	1-14	G.R.	12000	F.G.A.	Some stones; uniform profile throughout.
	3-13, 2-14	U.	1300	F.G.A.	Very few stones.
	2-14 to 4-15	U.-G.R.	26000	F.-F.G.A.	Few stones; variable profile depth.
1.3.2/6	7-5, 8-6	G.R.-R.	5000	Pr.-F.A.	Some stones.
	8-10	U.	1000	F.A.	Very few stones; some low land.
1.3.6	1-1	U.	1000	F.-F.G.P.	Some low land.
	1-14, 4-15	L.-U.	1000	Pr.-F.A.	20% to 25% surface eroded off.

TABLE VI.—Continued

Series	Location	Topography	Total Acres	Classification	REMARKS
1.4.2 (St.)	7-15	G.R.	1000	F.-F.G.P.	Very stony.
1.5.2	6-5, 3-7	U.-G.R.	2000	F.A.	
	6-12	G.R.-R.	1500	G.P.-F.A.	A wide drain.
1.5.2/0	4 & 5-7	L.	2300	F.-F.G.A.	Sand and clay lenses; part irrigated.
1.5.2/5	2-13 & 14	L.	400	Pr.-F.A.	A low basin.
	5 & 6-15	U.	1600	F.P.-F.A.	Bench above drain; stones few to many.
1.5.2/6	6-6	U.	800	Pr.-F.A.	Few stones; fairly deep profile.
	7-5, 3-13	G.R.-U.	4600	F.A.	Very few stones; basin areas.
1.5.5	8-8	L.	1000	F.P.-Pr.A.	Variable texture.
	2-11	L.-U.	700	F.P.	River flat.
1.5.6	5-5	L.-U.	1000	F.P.	Washed surface.
1.6.6	5-7	L.-U.	1500	Pr.-F.A.	Portion is in spring flood area.
SILT LOAM:					
1.6/2.2(Lt.)	6-11 to 8-14	U.	48000	F.-F.G.A.	Very few stones; fairly deep profile; much very fine sand.
1.6/2.2	6-11, 8-11	L.-U.	16000	F.G.A.	Very few stones; fairly deep profile.
1.7/2.2	8-11, 8-12	L.-U.	8000	F.G.-G.A.	Very few stones; medium to heavy texture.
1.3.2	3-9	U.	1000	F.A.	Occasional solonized profile.
	7-8 & 9	U.-G.R.	3200	F.-F.G.A.	Fairy deep profile; very few stones.
	1 & 7-15, 5-11	U.	4000	F.G.A.	Few stones; occasional solonized profile.
	6-15	U.	5500	F.-F.G.A.	Basin area containing sloughs.
	7-12 & 13	L.-U.	7000	F.G.A.	Few stones; heavier textured than 1.6/2.2 adjacent.
	8-15	L.-U.	15500	F.G.-G.A.	Very few stones; fairly deep profile.
1.3.2/6	3-10	G.R.	1000	F.A.	Very few stones.
	4 & 5-15	L.-U.	900	Pr.-F.A.	Very few stones.
1.3.6	1 & 8-15	L.-U.	900	Pr.-F.A.	
1.5.0	2-8, 2-9	L.-U.	2000	G.P.-F.A.	Milk river flood plain.
1.5.2/6	6-15	U.-G.R.	500	Pr.A.	Variable area.
1.7.2	1-1 & 2	L.-U.	1000	Pr.-F.A.	
1.7.6	2 & 3-12	L.-U.	700	F.G.P.-F.A.	About 40% surface eroded off.
CLAY LOAM:					
1.0.1	6 & 7-5	H.	2500	F.G.P.	Stony; a high ridge.
1.0.5	6-2	L.-U.	500	F.P.	Somewhat marshy.
1.0.6	3-1, 6-2	U.	4000	P.-F.P.	Numerous stones; badly washed.
	4-4, 6-1, 5-5	U.-G.R.	1000	F.P.	Stony.
1.0.6 (St.)	6-1 & 2, 4-3 3 & 4 & 5-4	U.-H.	25000	P.-F.P.	Washed, partly eroded, surface stones.
1.1.2	6-5	G.R.	2000	F.A.	Relatively shallow profile.
1.1.2/6	5 & 6-5	U.-G.R.	1000	F.P.-F.A.	Heavy textured.
1.1.6	7-5	R.	1000	F.G.P.	Stony escarpment.
	2 & 3-7	U.	3500	F.G.P.	Some marshes.

1.2/0.2	6-5	R.-H.	6000	F.G.P.-F.A.	Some stones.
1.2/0.2/6	4 & 5-1	G.R.-R.	16000	F.-F.G.P.	10% to 15% surface eroded off; stony.
1.2/0.6	3-3	G.R.-R.	1800	P.-F.P.	Stony; 75% surface eroded off.
1.2/0.6	2-9	G.R.	1000	F.G.P.	Some stones, and marshes.
1.5/0.6	3-1 & 2, 4-5	L.-U.	6500	P.-F.P.	Badly washed surface.
	6-1	L.-U.	1500	F.P.-Pr.A.	Very few stones.
	3-3 to 4-4	L.-U.	3000	F.P.	Creek basin; portions washed.
1.2.1	4-15	G.R.	1000	F.G.P.	A ridge with steep escarpment.
1.2.2	3-9, 4-8 & 9	G.R.-R.	45000	F.G.P.-F.A.	Variable in texture and stoniness.
1.2.2	6-1	R.-H.	7000	F.G.P.	Stony, many water-washed stones.
	7-9 to 6-15	G.R.-H.	80000	F.G.P-F..A.	Generally shallow profile; stony; choppy topography.
	4-11 to 4-13	G.R.	70000	F.-F.G.A.	Some stones; granular B_1 horizon.
1.2.2/6	6 & 7-7	G.R.	2300	F.-F.G.P.	Stony; slopes to the west.
	8-8	R.	1500	F.G.P.	Numerous stones; heavy subsoil close to surface.
	3-12 to 4-13	G.R.	5500	F.G.P.-Pr.A.	Shallow profile; some stones.
1.2.6	6-8	U.-G.R.	1500	Pr.A.	Some stones; a lower area.
	4-11, 4-12	G.R.-R.	1600	Pr.-F.A.	Marshy spots.
1.3.2	7-6 & 7, 8-8	G.R.	2000	F.A.	Few stones; occasional solonized profile.
	4-11, & 12 & 13	U.	6500	F.-F.G.A.	Very few stones.
	3-14 to 5-15	L.-U.	23000	F.G.A.	Fairly deep profile.
1.3.2/6	8-7 & 8	U.-G.R.	4500	F.A.	Very few stones, upper basin.
	5 & 6 & 7-8	U.-R.	5300	F.A.	Basin-like areas.
1.3.6	3-9, 6-8	U.-G.R.	1600	F.G.P.	Washed patches.
	7-5, 8-8	G.R.	2500	G.P.-Pr.A.	7-5 area cut by erosion.
	3 & 4-14, 5-15	L.-U.	1200	Pr.-F.A.	Some marshes, 20% solonized.
1.5.2	7-5	U.-G.R.	1500	F.-F.G.A.	Very few stones.
	1-1	L.-U.	700	F.A.	Low land, partly irrigated.
1.5.2/6	4-4	L.-U.	1200	Pr.A.	Delta areas in creek basin.
	7-5	U.	2000	Pr.-F.A.	Very few stones.
	4-7	L.	2000	F.-F.G.A.	Very fine sand to clay.
1.5.3/5	1-12	L.-U.	800	F.A.	Low basin; partly irrigated.
1.5.5	3-6, 4-7	L.	5000	F.P.	Washed; sage and greasewood.
	2 & 5-10	U.	2000	F.-F.G.P.	Coulee flats partly washed.
	1-13 & 14	L.-U.	1000	Pr.A	Low area, variable.
1.5.6	3-1 to 6-3	U.-G.R.	11000	F.-F.G.P.	Partly washed; some irrigated patches.
	2 & 3-4 & 7	L.-U.	3000	F.G.P.	Some marshes in western area.
	1-2 & 3 & 4	L.-U.	3500	P.-F.P.	Washed stream courses.
	2-4	U.	1800	F.G.P.-Pr.A.	Variable.
1.7.2	1-2	L.	900	F.-F.G.A.	No stones; irrigated.

SILTY CLAY LOAM:

1.3.2	4-15	U.	700	F.-F.G.A.	
1.5.5	7-14 & 15	L.	1700	G.P.-Pr.A.	Contains some arable deltas.
	3-15	L.-U.	800	F.G.P.	No stones; bench in coulee flat.
1.6.2	4-8 to 5-9	L.-U.	1500	F.G.A.	Fairly deep profile; very few stones.
1.7.5	4-15	L.	300	F.G.P.	Edge of slough.

REMARKS

Series	Location	Topography	Total Acres	Classification	REMARKS
CLAY:					
1.0.2	2-12 & 13	G.R.-H.	300	Pr.A.	
1.0.5	4-3 & 4-4	L.-U.	4000	P.-F.P.	Washed, portions eroded.
1.1.2 (St.)	6-1	G.R.	2500	F.G.P.-Pr.A.	Shallow profile; washed upland.
1.1.2/5	1 & 2-3	U.	1500	Pr.A.	No stones; variable area.
1.1.2/6	6 & 7-5	U.-G.R.	2500	F.A.	Basin surrounded by residual hills.
1.1.6	7-5	U.-G.R.	500	P.-F.P.	
1.7/2.2/6	6 & 7-7 & 8	L.-U.	4000	F.A.	Very few stones.
1.3.2/6	8-7 & 8	U.-G.R.	4000	F.A.	Very few stones.
1.3.6	7 & 8-7	L.-U.	2500	Pr.A.	
1.5.5	3-6, 3-7	L.-U.	1500	F.P.	Washed; edge of laking basin.
	7-8 to 8-11 7-10 to 7-13	L.-U.	15000	F.-F.G.P.	Coulee flats, much waste land.
	2-11	L.-U.	400	F.P.	Contains sand lenses.
	2-13 to 3-15	L.	4500	F.P.	Badly washed.
1.5.6	5-1, 5-2	L.-U.	3000	F.P.-F.A.	Better portions irrigated.
	2-2 to 3-3	L.-U.	4000	F.-F.G.P.	Stones variable; considerable sage growth.
	6-3	L.-U.	1500	F.P.-F.A.	Very few stones.
1.6.2/6	4-6 to 5-7	L.	1000	F.G.A.	No stones; sand lenses; partly irrigated.
1.7.2	4-15	L.	100	F.G.-G.A.	
1.7.2/5	1-1 & 1-3	L.	2,200	F.P.	Stream courses, considerable sage growth; some flood irrigation.
	1-2	L.	12000	Pr.-F.A.	Some sand in subsoil; some flood irrigation.
1.7.2/5	2 & 3-5	L.-U.	3000	F.G.P.-F.A.	Salts concentrated in lower portions.
	3-13, 3-14	L.	1300	Pr.-F.A.	Draws and laking basins.
1.7.5	1-2, 5-6 to 7-7	L.-U.	3500	P.-F.P.	Washed; greasewood growth.
	1-7, 4-7	L.	4000	F.P.	1-7 is an alkaline draw.
	2 to 3 & 4-8, 5-9	L.	7500	P.-F.P.	Coulee flats.
	8-8	L.	1000	P.-F.P.	Salty.
	6-8, 5-11	L.	2500	F.-F.G.P.	Marshy areas.
	4-14	L.	800	G.P.	Marshy.
	4-15	L.	200	F.P.	
1.7.6	7-7	L.-U.	1200	G.P.-Pr.A.	Somewhat marshy.
MIXED TEXTURE:					
1.5.0	1-5 to 2-9	L.-U.	10000	F.P.-F.A.	Variable deposition, in Milk river bed (see plate 7, fig. 3).

DARK BROWN SOIL SUB-ZONES

The Milk River sheet lies well within the large brown soil zone of south eastern Alberta. However, within this sheet are two sub-zones of darker colored soils both associated with topographic elevations.

Dark brown soils of Alberta are formed under an annual rainfall of about 15 inches. They are a dark brown color and have an average of about 0.25% nitrogen in the surface foot. In general the lime carbonate horizon is found at from 12 to 30 inches from the surface in dark brown soils and averages about 20 inches in this sheet.

The dark brown soils south of Milk River are associated with the Sweet Grass hills and are found at elevations of 3,400 feet up to at least 4,000 feet. The dark brown soils in the northeast corner of the sheet are associated with the Cypress hills plateau and are found at elevations ranging from about 3,300 feet to 4,200 feet.

Below is given a description of the major soil areas of dark brown soils in the Milk River sheet. Table VII gives the main properties of each individual soil area.

Glacial Loams of the Sweet Grass Hills Elevation.

Lying north of the Sweet Grass hills and including approximately the south half of township 1, ranges 10 to 13, is an area of dark brown heavy loam on glacial till (see plate 6, fig. 3). The topography is gently rolling to hilly and the area is cut by some deep coulees. Stones are variable in number but in only a few places are they numerous enough to prevent cultivation.

The profile in general is fairly friable. Although there is considerable grit present the clay content is high and on the long slopes where the A horizon is relatively shallow the texture is quite heavy. As is typical of most glacial areas there is considerable variability. This variation ranges from the shallower heavy textured hill slopes to the fairly deep and somewhat silty bottom and bench lands.

The area also has a variable utilization. Those lands that are too rough to cultivate are good to very good pasture lands. Those that are possible of cultivation in the main vary in arable value depending on the smoothness of the topography and the relative absence of stones. These lands vary from fair to good due to their broken nature. The arable fields in general are smaller than on the open prairie to the north. The area lends itself to a more mixed type of agriculture.

Hilly Loams Adjacent to Eagle Butte.

Stretching from tp. 6, range 3, through Eagle Butte and then west to the Bullshead in tp. 8, range 6, is an area of dark brown loams formed principally on residual parent material. The boundaries of the brown-dark brown soil division and the dark brown-shallow black division have been outlined earlier in this report. The soils of this group (all carrying the hundreds digit 2) lie between those two lines including and west of tp. 3, range 6. The major part of the area consists of many high residual ridges cut by deep draws.

The large area of 2.0.1 loam and heavy loam is formed principally of lower tertiary bedrock, mainly Whitemud. The predominance of long slopes from these ridges, slopes subject to some erosion, necessitated the use of the profile designation 1. The area, in general, is good pasture. Within the area there are, however, some fairly level benches or draws of arable land. In these the profile is fairly deep and quite friable. Surface stones are found throughout the area.

Included in this area are some 2.2.2 (glacial) loams and heavy loams. These soils lie along the northern fringe of the higher residual ridges. Areas are mapped north of Bullshead Creek and in tp. 8, range 6. The topography in the glacial deposition varies from gently rolling to hilly. These areas are more variable and lack the long smooth slopes found in the 2.0.1 areas. The glacial areas are from good pasture to fairly good arable depending mainly on the topography. The 2.2.2 heavy loam in tp. 1, range 8, is similar to the glacial areas described above. The more level areas just east of Bullshead in tp. 8, range 6, and adjacent to Wisdom in tp. 8, range 5, are fairly deep sorted soils and are good arable lands.

The dark brown soils of Medicine Lodge and Bullshead valleys are generally quite variable and in many cases have a washed surface. They carry the profile designation 6 or 2/6. The small areas, where some alluvial deposition covers the residual shale have some arable possibilities.

Residual Alluvial Loams South of Fox.

A relatively small area of dark brown soils lies in ranges 1 and 2 on a sloping plain below the main Cypress plateau. This plain is divided from the black soils of the top bench by a steep escarpment mapped as 2.0.1 heavy loam. This escarpment is pasture land.

Along the side and base of the escarpment flow numerous springs. It should be stated here that since the top bench slopes to the east and to the south much of the sub-drainage through the conglomerate bed rock finds an exit along this southeastern escarpment. Small water washed stones, coming originally from the Cypress conglomerate, are quite numerous on the lower bench; in places so thick as to prevent any attempts at cultivation. The springs mentioned above augmented by spring run-off, give a marshy appearance to the more level portions of the area. Many of the slopes to these level flood plains have strongly solonized soils and surface erosion has removed much of the A horizon.

The grass growth in the area varies from meadow grass in the moist spots to cinquefoil on the spring fed flats and to the more normal prairie grasses in the uplands. The area is fairly good to good pasture, its value being enhanced by the adequate supply of spring water. Due to the abundance of stones and the presence of solonized soil very little could be considered as arable land.

TABLE VII.—SOIL AREAS OF DARK BROWN SOIL SUB-ZONE

Series	Location	Topography	Total Acres	Classification	REMARKS
LIGHT LOAM:					
2.2/0.1	6-3 & 4	H.	1600	G.P.	Consolidated sandstone in profile.
LOAM:					
2.0.1	6-3 to 8-5	H.	3600	V.G.P.	Some arable patches in the draws.
2.0.2	6 & 7-1	R.	200	V.G.P.	
2.0.2 (St.)	6 & 7-1	G.R.	5000	G.P.	Sloping area; many water-washed stones.
2.1.1	7-3	G.R.	1500	F.G.P.	Sloping bank of creek.
2.1.2	7-3	U.	1200	F.G.A.	Some small stones.
	1-8	G.R.	2000	F.-F.G.A.	Fairly deep profile.
	6-3	G.R.	1400	G.P.	Inaccessible.
2.2/0.2	6-4	H.	4500	G.P.	Stony.
2.2/0.2/6	1-7 & 8	R.	5300	G.P.-Pr.A.	Some marshes.
2.2/0.6	1-8 & 9	R.	10000	G.P.	25% to 50% surface eroded off.
2.5/0.6	6 & 7-1	U.	3000	F.G.-G.P.	Marshy; running springs.
2.2.1	8-6	H.	4000	G.P.	Some stones.
2.2.2	8-5 & 6	G.R.-H.	12000	G.P.-F.G.A.	Some stones; high land.
	8-3 to 8-5	H.	9000	V.G.P.	Stony.
	8-4	R.	600	F.A.	Fairly deep profile.
2.5.0	8-4	U.	1600	F.G.A.	Some marshes.
2.5.2	1-12	U.-G.R.	600	F.G.A.	Creek flat; some gravel streaks.
2.5.2/5	7-4	L.-U.	1500	Pr.-F.G.A.	Occasional eroded spots.
2.5.2/6	6 & 7-3	U.	600	F.A.	Better portions of the valley.
	8-4	G.R.	400	F.-F.G.A.	A few stones.
2.5.6	6 & 7-3	G.R.	1000	G.P.-Pr.A.	Creek valley cut by erosion.
HEAVY LOAM:					
2.0.1	8-3 & 4	H.	3000	V.G.P.	Some hillsides are of residual clay.
	6 & 7-1	H.	6000	F.G.-G.P.	An escarpment.
2.1.1	6-2	R.	1600	G.P.	An escarpment.
2.1.2	6-2	L.-U.	600	F.G.A.	Gravel stones.
2.1.2 (Gv.)	6 & 7-2	G.R.-R.	7000	F.A.	Long slopes to the south.
2.1.6	6-2	L.-U.	800	F.A.	A lower bench.
2.2/0.1	7-4 to 8-5	H.	17000	G.P.	Fairly stony; valleys of arable land.
2.5/0.6	6-1	U.	1000	G.P.-Pr.A.	Somewhat marshy.
	6-2	L.-U.	3000	G.P.-F.A.	Low area, portions marshy.
2.5/0.6(Gv.)	6 & 7-1	U.	3000	G.P.	Creek beds; marshy.
2.2.2	1-9 to 1-13	G.R.-H.	42000	G.P.-F.G.A.	Fairly deep profile; some stones.
	8-1	R.H.	3000	G.P.-Pr.A.	Cut by draws.
	8-5 & 6	G.R.	3000	F.G.-G.A.	Slope to north from higher land.
2.3.2	8-6 & 7	G.R.	2000	F.G.A	Brown to dark brown in color.
CLAY LOAMS:					
2.3.2	1-13	U.	3500	G.A.	Fairly deep profile; portions cut by draws.
2.5.6	6-3, 8-4	U.-G.R.	1000	G.P.-Pr.A.	
CLAY:					
2.0.5	7-4	L.-U.	1000	F.P.	Washed; some hay meadows.
2.7.2/5	8-4	L.-U.	1500	Pr.-F.A.	Some alkali spots and occasional solonized profile.

SHALLOW BLACK, BLACK AND PODSOLIZED SOIL SUB-ZONES

The black soils of the Milk River sheet, like the dark brown soils of the sheet, are found as an island in the main brown zone; this island being the Cypress hills elevation.

The location of the line dividing the dark brown and shallow black soils in the Cypress hills has been given earlier in this report. It is drawn at about the 4,200 to 4,300 foot contour on the south and west, but is down to about 3,900 feet northwest of Elkwater Lake. There is a gradual rise in elevation from this line to the "Head of the Mountain" in tp. 8, range 3, which reaches an elevation of 4,800 feet. This zone includes as well as the top bench, the second bench in the Thelma district and some rolling land north of the north escarpment.

Black soils have a black A horizon and are definitely black in the plowed field. The nitrogen content of the surface foot averages from 0.25 to 0.50%. The black soils of the Cypress plateau have been formed under an annual rainfall of from 17 to 19 inches.

Gray wooded or podsolized soils in Alberta are found under heavy tree growth and moist soil conditions. Such soils are found associated with the timber growth on the Cypress hills. Only one area is mapped, however, as most of the tree covered escarpment is mapped as erosion.

Below is given a description of the major soil areas in these sub-zones. Table VIII gives the main properties of each individual soil area.

Black Soils of the Cypress Plateau.

Lying inside the dark brown and black sub-zone line and occupying portions of townships 7 and 8, ranges 1, 2 and 3, is a group of loams and silt loam soils mapped mainly as 3.0.2, 3.1.2 and 3.2.2 (shallow black).

Adjacent to Thelma is an undulating to gently rolling area, mapped mainly as 3.1.2, gravelly silt loam. This is a second bench and in general is unglaciated. The numerous gravel stones present throughout the profile are from weathered conglomerate, although the parent material on which the profile is formed is, in general, a formation geologically older than the Cypress conglomerate that caps the top bench. In this area the black horizon is from 3 to 6 inches deep and under this is a dark brown friable cloddy to prismatic horizon containing water washed stones. The lime concentration horizon was practically impossible to find. This is due possibly to a low initial lime content and to the fact that it was virtually impossible to dig more than 18 to 24 inches because of stones. Much of the area is cultivated and is fairly good arable land.

The top of the plateau extending from tp. 7, range 1, to tp. 8, range 3, is a level plain that slopes very gradually to the east and south. The entire area, unglaciated, is formed on the Cypress conglomerate parent formation. This conglomerate is quite deep. However, it is covered by from two to five feet of fine material that at present constitutes the soil profile. This mantle of fine material gradually thickens to the west and in tp. 8, range 3, at the high point of the plateau no gravel was found in the profile for at least two to three feet. This deeper covering is mainly within the 4.0.2 silt loam area. The following profile taken in section 10, tp. 8, range 3, is representative of this deep normal black area:

0″-10″—A. Black fluffy to friable cloddy loam to light silt loam.
10″-18″—A_2. Dark brown, cloddy, heavy loam.
18″-30″—B_1. Brown, cloddy, clay loam to silt loam.

A few stones were encountered at 30″, but otherwise there was no apparent change in profile.

Toward the east the mantle over the conglomerate gets thinner, as stated, and the depth of the black A horizon also gets shallower. In townships 7 and 8, range 1, the black horizon is from 4 to 6 inches deep. Excluding a few lone spruce trees, this top bench is an open plain. The principal growth is the shrub cinquefoil. Blue bunch grass, timber oat grass, and June grass are the dominant grasses. This area is cultivated to the edge of the forest reserve; inside the reserve boundary is pasture. The area is all good to very good arable land. However, care must be exercised in its cultivation. If soil drifting became serious and removed the thin mantle of fine material covering the conglomerate, the area would become a permanent waste of rock. At the present time brome grass forms an important part of each rotation. By such means serious soil drifting has been prevented.

The area north of the north escarpment is a mixture of glacial and residual soils, generally of rough topography and non-arable but very good pasture. However, portions, particularly immediately north of Elkwater Lake, are of undulating to gently rolling topography and are good arable lands. These soils are more of the variable glacial type and have some stones. The profile is generally fairly deep and the black horizon varies from 6 to 12 inches in depth.

In Medicine Lodge valley opposite the southwest corner of tp. 8, range 3, and in a draw west of Elkwater Lake, there are some valley soils mapped. These carry the deposition number 5. These areas are quite variable; they contain patches of alkaline soils and areas of solonized soil. However, in the main they are fairly good arable lands particularly for the growth of hay crops (see plate 3, fig. 3).

Podsolic Soils of the Cypress Hills.

Although only one area of podsolic soil is mapped, a 5.0.2 loam in townships 7 and 8, range 3, most of the northern tree covered escarpment is podsolized. In these areas the soil profile is a gray brown color to the surface and is capped by a thin layer of leaf mold. Part of the 5.0.2 area is on the edge of the upper bench and borders the 4.0.2 silt loam. In this portion of the area there is a 3 to 6 inch gray leached layer below a 3 inch black surface horizon.

This paragraph, giving a brief description of the wooded soil on the Cypress hills is included in this report principally as a matter of record. It has been formed under a rainfall of about 18 to 19 inches annually, a mean annual temperature of about 40 to 41 degrees Fahrenheit and a fairly heavy growth of both evergreen and deciduous trees. The main wooded or podsolic soil zone of Alberta lies west and north of Edmonton.

TABLE VIII.—SOIL AREAS OF BLACK AND TRANSITION SOIL SUB-ZONE

Series	Location	Topography	Total Acres	Classification	REMARKS
				SHALLOW BLACK	
LOAM:					
3.0.1	8-1, 2 & 3	H.	8000	V.G.P.	North slope of Cypress hills.
3.1.2	7 & 8-2 & 3	G.R.	4000	F.G.-G.A.	Areas in 8-3 have gravelly subsoil.
3.2.1	8-2	H.	2000	V.G.P.	Very stony; some sloughs
3.5.0	8-1	U.	400	F.G.A.	Creek bottom.
3.5.2	7-3	U.	2000	F.G.-G.A.	Some good arable benches; very few stones.
3.6.2	8-5 & 6	U.	600	G.A.	Uniform area at edge of lake.
HEAVY LOAM:					
3.0.1	7-2	H.	2500	G.P.	An escarpment.
3.2.2	8-3	H.	2000	V.G.P.	Stony; long slopes.
SILT LOAM:					
3.0.2	8-2	L.-U.	10000	G.A.	Conglomerate close to surface.
3.0.2 (Lt.)	7 & 8-1	L.-U.	14000	G.A.	Slightly shallower profile than 3.0.2 above.
3.1.2	7-3	U.	6000	G.A.	Water-washed stones in subsoil.
3.1.2 (Lt.)	6-2 & 3	L.-U.	1000	F.G.A.	Relatively shallow black horizon.
3.1.2 (Gr.)	7-2	G.R.-R.	8500	F.G.A.	Subsoil very gravelly.
CLAY LOAM:					
3.3.2	8-3	G.R.	200	G.A.	A slightly lower area.
3.5.6	8-4	L.-U.	900	F.G.P.-F.A.	Variable.
CLAY:					
3.1.2	7-2	L.	200	Pr.A.	Somewhat washed, stony.
3.5.2/5	7-3 & 4	U.	600	F.G.A.	A few alkaline spots.
				BLACK	
LOAM:					
4.5.2	8-3	U.	400	G.A.	A wide draw.
SILT LOAM:					
4.0.2 (Lt.)	8-3	L.	2200	G.-V.G.A.	Top of plateau; deep deposition over conglomerate.
				TRANSITION	
LOAM:					
5.0.1	7 & 8-3	R.	1700	F.G.P.	Tree growth; profile somewhat podsolized.

ERODED LANDS

Eroded land makes up almost 11% of the total area of this sheet. This is a very high percentage, particularly when it is remembered that much af the area mapped as eroded is waste land. Much of the erosion is along coulee and river banks, although there are large blocks of eroded land mapped east of Manyberries that are not along main drainage ways. The erosion on this sheet can be divided into three groups. Group I includes the grass covered slopes of drainage ways. These banks are too rough or steep to cultivate but have considerable pasture value. Fortymile, Chin, Etzikom, and Verdigris coulees and the Milk River banks as far east as Pendant d'Oreille coulee are in this group. Group II includes the bad land areas that are practically devoid of vegetation, that is, bare parent rock exposures (see plate 4, fig. 1). Milk River east of tp. 2, range 8, Lodge creek, Sage creek and many of the bad lands east of Manyberries are in this group. These lands have practically no pasture value and in many cases are inaccessible even to stock. Group III includes the slope from the Cypress plateau. This block of erosion is mainly covered with tree growth, much of it of commercial value. Some pasture is found among the trees.

MARSHES AND LAKES

Marshes and lakes make up less than one and one-half per cent of the total area of this sheet. Elkwater lake is the only permanent lake of any size. Pakowki lake as described elsewhere in this report is an intermittent lake and only in very wet periods does it contain water. There are no large natural hay meadows in the area and relatively few small sloughs. The morainal area south of Etzikom coulee and adjacent to Etzikom has, however, a fair number of small sloughs and meadows containing meadow grasses. The residual area east of Pakowki lake has very few basins that collect and hold water.

COMPOSITION OF SOILS OF THE MILK RIVER SHEET

The nitrogen, phosphorus, calcium and magnesium contents were determined on soil samples taken in the Milk River sheet. Only a few representative profiles are reported in Table IX. These profiles were selected to give a fairly complete coverage of the main soil areas. Profiles from two of the sub-zones are reported in this table. These sub-zones are relatively narrow strips of land associated with the Cypress hills and Sweet Grass hills elevations (see description of soils). There is a marked increase in the soil's organic matter content in most of these sub-zones. The average nitrogen content of the surface foot increases over 300% between the Ranchville district and the top of the Cypress hills, a distance of about 10 miles.

The average nitrogen content (calculated on the surface foot) of seventeen brown soils in the west half of the sheet was 0.139% and of eighteen brown soils in the east half of the sheet was 0.115%. It has been stated earlier in this report that the west half of the sheet receives a little more rainfall than does the east half. The figure of 0.139% is slightly higher than the average nitrogen content of the brown soils of southeastern Alberta; the figure of 0.115% is considerably lower than the average. Two dark brown soils, one from the Sweet Grass hills and one from the Cypress hills averaged 0.242% nitrogen in the surface foot; one shallow black soil from the Thelma district had 0.325% and a normal black from tp. 8, range 3 (the top of the plateau) had 0.448%. A gray leached soil from the wooded escarpment had only 0.066% nitrogen in the surface foot. The above figures for the dark brown and the shallow black soils are slightly higher than the averages for similar zones reported in previous Alberta soil survey publications.

The variation in nitrogen content of the brown soils is, in general, not great. The lowest sample analyzed was a sand from the Lake Pakowki area; this sample had 0.03% nitrogen in the surface foot. The highest analyzed sample was a sorted silt loam in tp. 8, range 15, which had 0.178% in the surface foot. Excluding these two samples, the variation was from 0.08 to 0.16% nitrogen in the surface foot.

In practically all cases there was a decrease in nitrogen content from the surface down. Table IX illustrates this, the decrease in most cases being quite large. Since most of the nitrogen is in the surface or A horizon the loss of that surface by erosion means not only the loss of much fertile soil but exposing for production a soil much lower in natural fertility. Out of approximately forty profiles analyzed only two showed any appreciable increase in nitrogen content in the B horizon. Both of these profiles were taken in the strongly solonized area southeast of Manyberries. The hard waxy B_1 horizons in these two profiles had a higher nitrogen content than did the light textured A horizon.

The average phosphorus content (calculated on the surface foot) of twenty-eight brown soils was 0.049%; of two dark brown soils was 0.061%; of one shallow black was 0.070%; and one normal black was 0.140%. Two lacustrine clays that averaged about 0.070% in the surface foot had the highest phosphorus content of any of the brown soils analyzed. These samples were from Pakowki lake and the flat in tp. 1, range 2.

TABLE IX.—CHEMICAL COMPOSITION OF REPRESENTATIVE SOIL PROFILES

Sample No.	Depth in inches	Horizon	Per Cent N	Per Cent N first 12″	Per Cent P	Per Cent Ca	Per Cent Mg	pH	P (pH3) p.p.m.
1.3.2—Silt loam, undulating—21-8-15-4									
1039	0-4	A	0.261		.053	0.68	0.51	7.6	45
1040	4-10	B1	0.135		.046	0.41	0.54	7.2	43
1041	10-16	B2	0.141	0.178	.075	6.28	1.17	8.1	58
1042	at 20	C	0.072		.052	5.67	1.31	8.6	....
1.6/2.2—Light silt loam, undulating area—22-8-13-4									
1036	0-6	A	0.174		.054	0.63	0.37	7.3	45
1037	6-17	B1	0.095	0.134	.045	0.49	0.53	7.2	50
1038	17	B2	0.079		.051	3.12	0.67	8.1	63
1.5/2.2—Loam in undulating to gently rolling area—16-7-11-4									
1028	0-5	A	0.149		.043	0.56	0.46	7.3	55
1029	5-11	B1	0.132		.044	0.69	0.55	7.3	46
1030	11-15	B2	0.097	0.136	.048	4.19	0.87	8.2	95
1031	at 20	B2 or C	0.068		.061	4.54	1.01	8.3	....
1.3.2—Heavy loam in level to undulating area—19-6-13-4									
1047	0-4	A	0.175		.055	0.69	0.58	7.5	85
1048	4-12	B1	0.103	0.127	.054	0.69	0.61	7.8	68
1049	12-18	B2	0.074		.059	4.64	1.20	8.5	80
1050	at 24	B2 or C	0.056		.050	4.14	1.09	8.4	88
1.3.2—Heavy loam in undulating to gently rolling area—21-5-10-4									
1081	0-4	A	0.181		.055	0.71	0.50	7.4	58
1082	4-15	B1	0.102	0.128	.043	0.63	0.55	7.5	45
1083	15-22	B2	0.095		.056	5.54	0.98	8.2	68
1084	at 32	C	0.052		.048	4.78	0.99	8.7	....
1.3.2—Heavy loam to clay loam in gently rolling area—12-1-14-4									
1070	0-4	A	0.191		.061	0.81	0.48	7.6	98
1071	4-12	B1	0.126	0.146	.053	0.94	0.66	7.6	88
1072	12-16	B2	0.108		.061	5.78	0.89	8.2	56
1.2.2—Clay loam in gently rolling to rolling area—7-4-11-4									
1025	0-6	A	0.193		.049	0.62	0.54	6.2	60
1026	6-12	B1	0.136	0.164	.042	0.63	1.01	7.5	75
1027	12-18	B2	0.064		.045	3.31	1.04	8.0	80
1.5.7/2—Light loam in Pakowki flat—36-3-7-4									
1157	0-10	Surface	0.094	0.086	.051	2.68	1.19	8.6	68
1158	10-20	Sub-surface	0.047		.042	3.34	1.26	8.8	40
1159	20-30	Sub-soil	0.019		.049	3.08	1.32	9.9	73
1.5.2—Clay in Pakowki flat—1-5-7-4									
1160	0-12		0.158	0.158	.057	0.69	0.85	7.0	100
1161	18-24		0.091		.048	0.87	0.73	7.5	105
1162	28-36		0.055		.039	1.35	0.73	7.7	85
1.1.2/6—Loam in gently rolling area—27-2-6-4									
1176	0-4	A	0.191		.041	0.50	0.39	6.8	30
1177	4-12	B1	0.085	0.120	.042	0.57	0.50	7.4	38
1178	12-20	Lower B1	0.089		.054	0.66	0.61	7.4	68
1179	20-30	B2	0.053		.053	4.69	1.28	8.2	48
1.2/0.6—Light loam in gently rolling area—13-4-3-4									
1119	0-5	A1	0.108		.035	0.39	0.25	6.1	17
1120	5-7	A2	0.060		.027	0.44	0.28	7.1	12
1121	7-12	B1	0.111	0.101	0.29	0.48	0.82	8.3	25
1122	12-18	B2	0.086		.037	1.29	0.85	8.7	78
1123	at 20	C	0.066		.059	1.50	0.86	8.4	44
2.2.2—Heavy loam in rolling area—9-1-12-4									
1073	0-6	A	0.312		.062	0.65	0.48	7.1	43
1074	6-14	B1	0.185	0.248	.054	0.66	0.60	6.8	45
1075	14-20	B2	0.137		.065	6.09	0.99	8.1	63
1076	24-30	C	0.078		.050	6.49	1.06	8.0	63
3.0.2—Silt loam in level to undulating area—24-7-3-4									
1146	0-6	A	0.510		.099	0.72	0.39	5.9	15
1147	6-11	Lower A	0.144		.044	0.52	0.50	5.7	18
1148	11-18	B1	0.098	0.325	.028	0.61	0.59	6.0	15
1149	18-24	B1 or B2	0.055		.028	0.64	0.55	6.5	20

The lowest total phosphorus content was found in two residual profiles east of Manyberries; they averaged 0.032 in the surface foot. The remainder of the brown profiles ranged from 0.041 to 0.058% in the surface foot. As can be seen from Table IX, the phosphorus content does not change greatly with depth. In many cases, however, the B_1 horizon has a lower total phosphorus than the A_1 or lower B_2 horizons. In general, the readily available phosphorus (determined at pH3) did not change much with depth. The lowest brown soil analyzed was a solonized residual profile from east of Manyberries. The shallow black soil had considerably less available phosphorus than the average brown soil.

The lime content of the soils of this sheet is about average for the brown soils of southeastern Alberta. One area of profile 2/7 was mapped in Pakowki flat. This area of alluvial deposition has a fairly high lime concentration to the surface, over 2% calcium in the surface foot. This, however, is exceptional in this sheet. The thirty profiles analyzed for calcum and magnesium gave an average of 0.6% calcum and 0.5% magnesium in the A horizon and 3.3% calcium and 1.0% magnesium in the B_2 and upper C horizon. Excluding the high lime sample mentioned above, a sample taken in a hilly area where surface erosion had removed most of the A horizon and a sample from Green Lake, the variation in calcium in the A or surface horizon was from 0.4 to 1.1%, and in the subsoil from 0.5% to 6.5%. The variation in magnesium was from 0.2 to 1.0% in the surface horizon and from 0.5 to 1.3% in the subsoil. The above figures indicate that the soils of the Milk River sheet are not deficient in either calcium or magnesium.

The two black profiles and the leached profile taken on the Cypress hills did not show any concentration of calcium or magnesium to the depth sampled, that is, down to the point where the profile became too stony to conveniently sample. It is possible that there might be a lime concentration horizon at a greater depth, although there is considerable drainage through the underlying conglomerate. A 0″ to 10″ sample from the bed of Green lake in tp. 6, range 1, had about 5.5% calcium and nearly 2.0% magnesium. This was the highest magnesium concentration determined on the sheet.

The calcium and magnesium as a rule are lowest in the surface horizon and highest in the subsoil. This is accounted for by the fact that, being slightly soluble, they are carried downwards by the penetrating rain water. The magnesium of the soil is less soluble than the calcium, and the plants demand less magnesium than calcium. Thus the ratio of calcium to magnesium is narrower in the surface than in the subsoil. That portion of the profile where the transported calcium and magnesium is concentrated has been called the B_2 horizon; that concentration often carries down to what has been sampled as upper C horizon.

No potassium analyses were made but previous analyses, including some made on soils from the east side of the Lethbridge sheet, indicate that the brown soils of southeastern Alberta have a total potassium content of from 1.0 to 1.75%. Some other elements essential for plant growth, namely iron, sulphur and manganese are generally present in large quantities as compared with the amounts required by crops.

If the total figures as reported in Table IX were converted into crops theoretically producible, it might seem that the supply of essential plant foods 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 elements dissolve slowly or become available slowly and only in their available form can they be used by the plant. 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 than in cropped soil. However, the percentage of organic matter in the brown and dark brown soil zones of this sheet is relatively low and therefore the amount of essential elements coming into solution by such a process might be limited.

Although soil moisture as a limiting factor in crop production should be emphasized in all soil zones the importance of soil fertility should not be disregarded. Among other things the efficiency of a unit of soil moisture will vary directly with the concentration of the soil solution. This, in turn, depends on the amount of readily available essential elements so that, although there is an abundance of total plant food elements in the soil, the plant may be starved because there is not enough food readily available. Much of the available food is in the surface soil and the removal of this surface through soil erosion seriously reduces the immediate as well as the potential productive capacity of the soil.

The reactions of the profile are given in Table IX. From the figure it is seen that most of the profiles are very close to the neutral point. They average about pH 7 in the surface horizons and pH 8.5 in the subsoils. The higher subsoil pH is due principally to the presence of lime. The profile of 3.0.2 silt loam reported in Table IX ranged from pH 5.7 to 6.5. The profile of 4.0.2 silt loam from the top of the Cypress hills ranged from pH 5.3 to 5.5 and the 5.0.2 loam from the wooded escarpment ranged from pH 5.3 to 6.0. The above three profiles were the only ones that were below pH 7.0 in all horizons analyzed. However, it was stated earlier in this section that a lime concentration horizon was not found in these profiles from the Cypress hills at the depth sampled.

ALKALI

Soils are formed by the weathering of rock materials and alkali salts come originally from this decomposed rock. Since some of the parent material, particularly shales, is of marine formation it contains various salts, and these salts when set free by the decomposition of the rocks tend to accumulate wherever the rainfall is not sufficient to dissolve and carry them off in the drainage water.

Alkali lands usually occur in areas where the annual rainfall is less than twenty inches. Alkali generally appears in the valleys and depressions that receive the drainage from the surrounding soils and from which there is no drainage outlet. However, alkali may occur in level land that is not too well drained even though the land is slightly elevated.

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 bicarbonate of sodium, and owes its name mainly to the fact that when this alkali 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 times 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 often 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 soil and causes it to become tough and impervious. White alkali has a less injurious effect upon the physical condition of soils and sometimes 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 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 representative of various soil types on the Milk River sheet were analyzed; only representative profiles and samples, however, are reported in Table X. The first two profiles reported in this table, namely 1047 to 1050 and 1085 to 1088, are typical of much of the west half of the sheet. Both profiles have negligible quantities of water soluble salt; the sorted soil has very little more than a trace even in the "C" horizon.

Many productive semi-arid soils contain from .25 to .50 of one per cent of water soluble salts. Most of the Alberta semi-arid soils contain less than .1 of one per cent total water soluble salts. Soils containing more than .50 of one 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 were there no calcium sulphate present, since this salt, partly by its flocculating action, ameliorates the toxic effect of the other alkali salts.

In most of the profiles reported in Table X the percentage of water soluble calcium is not high although the total calcium in the B_2 and C horizon averages between 4 and 5%. Black alkali may be toxic in concentrations exceeding 0.1%. Out of all samples analyzed, only 4 individual samples had over 0.1% sodium carbonate and bicarbonate and none had over 0.2%. The sodium reported in this table was obtained by difference. That is, the sodium is calculated to make up the difference in positive ions necessary to link with all the anions determined.

Samples 1157 to 1159 and samples 1160 to 1162 are two profiles from Pakowki flat and represent the two main series types in this area, much of which is flood irrigated. Both profiles are quite low in total alkali salt content and would appear to be safe irrigation soils. The subsoil of the light loam profile has a fairly high bicarbonate content. There is a gradual westward slope to the centre of the lake permitting drainage in that direction. Sample No. 1089 is from the heavy textured lacustrine bed of present Lake Pakowki. The native vegetation on the lake bed is composed mainly of alkali tolerant varieties. The total non-volatile salt content of this sample was 1.38%, and was one of the highest found on the sheet. The principal salt is sodium sulphate.

Sample 1194 is from a clay basin in tp. 1, range 2, that appears to be somewhat like the Pakowki basin. Portions of the flat are irrigated. The above sample was taken near the centre of the basin in a spot that was nearly devoid of vegetation. Sulphate is the most abundant anion present and sodium the most abundant cation. This profile contains a high enough salt content to be considered dangerous, but it is quite possible that nearer to the edge of the basin the total salt is below the toxic limit.

Samples 1119 to 1123 is a profile fairly typical of the sorted residual and glacial residual solonized soils southeast of Manyberries. The total non-volatile salts are below the toxic limit even in the C horizon. Most of these areas are formed on bed rock of upper Belly River and lower Bearpaw, that is of fresh to brackish water deposition. Samples 1124 to 1126 is a profile typical of the marine laid Bearpaw soils of the area. Vegetation is sparse on these 1.0.6 areas, but the native varieties that are growing here are not necessarily alkali resistant. The total salt content of this profile is relatively high, but it is mainly calcium sulphate (gypsum), a salt common to the Bearpaw shales. As stated earlier in this section, gypsum is not nearly as toxic as some of the other salts.

Samples 1127 to 1130 is a profile taken from one of the alluvial fans found in the eroded valleys east of Manyberries. This profile contained only a trace of alkali. Such fans may be desirable soils to irrigate from coulee dams. In general these better alluvial areas are surrounded by semi-eroded, somewhat alkali soil areas that are mainly non-arable. These latter areas are mapped as profile 5.

Samples 1183 to 1185 is a profile taken from the dry portion of Green Lake. This lake is fed by springs from Cypress hills. This profile does not have a high salt content for an inland lake. It differs, however, from most of the profiles analyzed from this sheet in that there is a greater quantity of water soluble magnesium present than there is calcium. The principal anion is sulphate. Wild barley is the principal grass along the edge of the lake.

Samples 1140 to 1145 is a profile of dark brown soil having a waxy B horizon. The Whitemud formation is the parent rock in this area. The salt content is low to the bottom of the B_2 horizon. The C horizon has 0.71% total salts divided fairly equally between the sulphates of calcium, magnesium and sodium.

The samples analyzed from this sheet indicate that, in general, the salt content is not high. Gypsum was the most common water soluble salt found. Many of the draws, particularly east of Manyberries have been mapped as profile 5. These areas have varying amounts of alkali salt. In general they are non-arable particularly under the low rainfall received in this area. Many of these areas have a very sparse vegetative growth and often have a washed surface. The soil covering over the parent rock is quite shallow.

TABLE X.—WATER SOLUBLE OR ALKALI SALT OF THE MILK RIVER SHEET

Sample No.	Location	Horizon	Depth	Remarks	Non-Volatile Solids	HCO3 and CO3	Cl	SO4	Ca	Mg	Na
1047	19-6-13	A	0″- 4″	1.3.2 H.L. to Si.L. Typical of sorted loams	trace						
1048	"	B1	4″-12″	west of Foremost.	trace						
1049	"	B2	12″-18″		0.08						
1050	"	C	at 24″		0.06						
1085	34-3-10	A	0″- 3″	1.2.2 H.L. to C.L. Typical of glacial soils	0.05						
1086	"	B1	3″- 8″	south of Foremost.	0.10						
1087	"	B2	8″-16″		0.12						
1157	36-3-7	Surface	0″-10″	1.5.2/7 Lt. L. Fluvial area in Pakowki	0.02						
1158	"	Sub-surface	10″-20″	Lake flat	0.09						
1159	"	Subsoil	20″-30″	Portions flood irrigated.	0.13	0.13					
1160	1-5-7	Surface	0″-12″	1.5.2 C. Fluvial area in Pakowki Lake flat.	0.03						
1161	"	Sub-surface	12″-24″		0.05						
1162	"	Subsoil	24″-36″	Portions flood irrigated.	0.07	0.037					
1089	18-3-8	Surface	0″- 8″	1.7.5 C. Pakowki Lake.	1.38						
1194	13-1-2	Surface	0″- 8″	1.7.5 C. The better portions of this flat	0.56	0.016	0.027	0.391	0.055	0.022	0.082
1195	"	Sub-surface	8″-12″	are cultivated.	0.56	0,020	0.030	0.367	0.029	0.020	0.104
1119	13-4-3	A	0″- 5″	1.2/0.6 Lt.L. Typical of much of the light	trace	0.008					
1120	"	A2	5″- 7″	surface solonized soil east of Many-	0.004	0.015					
1121	"	B1	7″-12″	berries.	trace	0.030					
1122	"	B2	12″-18″		0.06	0.071					
1123	"	C	20″-24″		0.11	0.063					
1124	19-3-4	A & B	0″- 4″	1.0.6 C.L. Bearpaw shale is the parent	0.21	0.030	0.011	0.134	0.037	0.013	0.001
1125	"	B	4″-10″	material in this soil.	0.95	0.027	0.007	0.672	0.148	0.050	0.058
1126	"	C	10″-18″		1.25	0.029	0.015	0.896	0.205	0.055	0.066
1127-8	11-4-4	A	0″- 7″	1.5.2/6 L. Alluviated fans in eroded valley	trace						
1129-30	"	B	7″-20″		trace						
1183	24-6-1	A	0″- 3″	Green lake bed.	0.21	0.117	0.005	0.148	0.015	0.023	0.006
1184	"	B	3″- 6″		0.40	0.057	0.005	0.256	0.017	0.033	0.04
1185	"	Lower B	6″-10″		0.71	0.049	0.007	0.474	0.021	0.056	0.096
1140-2	34-7-4	A	0″-18″	2.1.4 H.L. This is an arable bench in the	trace						
1143	"	B1	18″-26″	2.0.1 area. Whitemud formation is the	0.02						
1144	"	B2	26″-32″	parent material in this area.	0.12						
1145	"	C	32″-38″		0.45	0.034	0.019	0.306	0.036	0.028	0.048

FARM PRACTICE

The purpose of the soil survey is principally to locate and map areas of soil according to their agricultural desirability. Each area on the soil map carries a three digit number as well as the soil texture designation. Each of these numbers indicates a specific characteristic of the soil profile and each of these affects the soil's adaptability or possible utilization. Included in this report is a land classification map of the Milk River sheet. There are three grades of pasture land and three grades of arable land mapped in this sheet, ranging respectively from poor to excellent pasture and from poor to good arable. These grades are calculated mainly from the physical data obtained in the field on the basis used in this survey, namely traverses one mile apart; the economic and social factors, excepting in so far as they have determined the kind and yields of crops grown, did not enter into this classification. A fuller description of this map is given on page 88. Lands vary in their productive capacity and adaptability and it is generally recognized that many of the failures on Alberta farms are attributable to an incorrect utilization of those land areas. In this regard the best utilization of any land area will tend to get the most economical returns from the land without causing any unnecessary immediate or permanent deterioration.

The Milk River sheet lies well within the brown soil zone. The two islands of darker colored soils, namely the area at the base of the Sweet Grass hills and the area around the Cypress Hills, will be dealt with in a separate paragraph and will not be considered in the following discussion on general farm practices of the Milk River sheet.

In the section on climate it is stated that the annual rainfall varies from about 12 inches on the east side of the sheet to about 14 inches on the west side. This relatively low total rainfall is coupled with a relatively high evaporation. Records kept at Manyberries Range Station show an average annual evaporation of 32 inches between May and September inclusive, from a free water surface. The above statement emphasizes the fact that the utilization of the available moisture is of major importance in this area. Two statements can be made at this time; the first is that the type of farming practiced must make the best possible use of the available moisture, the second is that only the better soil types should be considered as arable lands since inferior soil types will not produce satisfactory yields under the limited rainfall available. · The large fluctuation in total rainfall and in rainfall distribution, typical of the brown soil zone, is an important factor in determining the type of farming practiced.

The Alberta soil survey has estimated that there are only about 615,000 acres or slightly over one-quarter of the total area of the sheet cultivated, with an additional 50,000 acres abandoned (see cultivation map). It would appear, therefore, that ranching is an important industry in this area. In a general way the east and southeast portion of the sheet is principally a ranching area, the northwest quarter of the sheet is principally a farming area and the remainder a combination of ranching and farming. Farming and farm practices will be dealt with first.

The large blocks of cultivation are located principally in the west half of the sheet, that is west of a line drawn from Seven Persons Coulee in tp. 8, range 8, south to Pakowki Lake and then southwest to Aden in tp. 1, range 10. The cultivation east of this line is patchy and contains considerable abandoned land.

As stated earlier in this report, about 50,000 acres of land, once cultivated, are now abandoned. The greatest amount of abandonment is east of Pakowki Lake, principally adjacent to Manyberries, Catchem and Pendant o'Oreille. There is also some abandoned land in the Groton, Lucky Strike and Writing-on-Stone districts, in the southern part of the sheet. In general these abandoned farms are located on the inferior soil types of the lower rainfall sections of the sheet. If left to themselves these lands will gradually become reseeded to native grasses and become useful pasture. This natural regrassing is, however, a slow process and considerable work in the field of artificial regrassing is being done. Experiments to date have indicated that crested wheat grass is suitable for this work. With this grass some abandoned fields have produced fairly good pasture in two or three years time. Very little of the abandoned land in this sheet is on sandy areas. There has, therefore, not been so great a need for emergency regrassing to hold moving sand as there has been in some other sections of the province. Whether or not more of the poorer land will be abandoned in the future will depend in a large measure, on economic trends. Abandoned land is a distinct loss in at least two respects; one is the loss of capital spent in bringing such land under cultivation and the other is the loss of pasturage while the regrassing process is in progress. It would, therefore, seem highly desirable to prevent the cultivation of inferior soil types.

There is, however, a fairly large acreage of the better soil types in this sheet and, in general, these are still being farmed. Although the bulk of this cultivation is in the west half of the sheet where the annual rainfall is between 13 and 14 inches, conservation of the available moisture is still of prime importance. This conservation takes among other things, the form of storing moisture by summer fallow, prevention of loss of soil moisture through transpiration by weeds, maintaining a trash cover and a ridged surface to hold the snow; in places contour furrows aid in reducing the run-off water loss.

By carefully controlled experiments it has been found that growing plants use a surprisingly large amount of water; the amount varies with the kind of crop and the growing conditions present. The average of many determinations and with many crops is over 400 pounds of water for one pound of dry matter. The loss of water by evaporation and run-off would bring this figure considerably higher. Under actual farming conditions in southern Alberta the wheat crop has required 1,500 pounds of water to produce one pound of dry matter. This means that over 3,000 pounds of water are required to produce one pound of grain and one pound of straw. With the average yield calculated at 11 bushels, and the precipitation around 13 inches for the greater portion of the sheet, the farmer therefore obtains only 0.8 bushels for each inch of rainfall. When it is considered that much of the area is fallow each year the average is less than 0.5 bushels per inch. Since, up to a certain limit, increased available moisture means greater rainfall efficiency in the crop produced, every effort should be made to conserve as much of the precipitation as possible. Many farmers by improved cultural practices have increased the efficiency of the rainfall.

Experiments at Swift Current Experimental Station show that wheat on fallow only required about two-thirds as much moisture to produce a bushel of grain, as did a crop of wheat following wheat. Further experiments there, also showed that wheat competing with tumbling mustard required almost twice as much moisture, and wheat competing with Russian thistle, three times as much moisture to produce one pound of dry material, as was required when no weeds were present. This fact should be of particular interest, considering the widespread occurrence of Russian thistle in the cultivated areas of this sheet. It may also be of interest to note that Russian thistle had the lowest water requirement of any of the plants studied at the Swift Current station. This would seem to explain its ability to compete so successfully with the grain crops, especially in the drier seasons.

The two year wheat fallow rotation is the generally accepted practice in this sheet. In view of what was said above, it is important that the fallow be kept free of weeds. A fallow that has a luxuriant growth of weeds is not conserving any moisture. This requires starting the summer fallow early. Possibly the process should be called spring fallowing instead of summer fallowing to emphasize the importance of getting on the land before the weeds have sapped away all the available moisture.

In general the farmers of this area favor the plowless fallow; that is fallowing to keep the trash on top. It has been adopted, probably as much as an economy measure as it has for its ability to control soil drifting. Yield tests at the Lethbridge Experimental Station indicate that there is no decrease in yield with the plowless fallow. For the years 1929 to 1934 the average yield of wheat on plowless fallow was 19.4 bushels per acre and on plowed fallow was 17.4 bushels. The fallow should be left over winter in such a condition that it will prevent spring run-off as much as possible. Some farmers have tried a form of dam listing to hold this run-off (see plate 8, fig. 2). The value of this has not yet been proved. It has the disadvantage of requiring levelling prior to seeding. It should be pointed out here that the plowless fallow depends for its success on there being a reasonable amount of trash to leave on top. If due to drought or other conditions the land is practically bare, the plowless fallow may leave the land surface more vulnerable to the winds than the plowed fallow. When there is insufficient trash cover listing or some other control measure may be necessary to prevent soil drifting. Some farmers have found it advisable to periodically plow their land, to return it to the desirable lumpy structure and also to prevent the formation of a hard sole below the cultivated surface. Some concern has been apparent this last year or two over the fact that Say's grain bug, a green triangular shaped beetle, hibernates in this trash and is increasing in numbers.

The two year wheat-fallow rotation is today the accepted practice on this sheet, as on most of the cultivated areas of the brown soil zone. However, it must be pointed out that this practice tends to reduce the soil's supply of organic matter and consequently of nitrogen. Organic matter is constantly decomposing in the soil. When land is fallowed the increased air and moisture favor a more rapid decomposition of the organic matter and at the same time no new organic matter is being added to replace that which is decomposed. Analyses conducted at the University of Alberta indicate that there is a drop in the nitrogen and carbon content of cropped land as compared with the native sod. Most of the fields sampled had been cultivated for over twenty years and have been in a grain fallow rotation. Such a loss of organic matter not only reduces the natural fertility of the soil, but it also reduces its water holding capacity and reduces its resistance to the drifting action of the wind. If the fertility of these soils is to be maintained even at their present level grass must be included in the rotation. The farmers of this area, as in other parts of the province, must realize that we cannot continue to take out without making provision for some putting back. Even the better soil types of the brown soil zone are too close to the margin of profitable production, to allow for much deterioration. The success attained in the seeding down of these wheat lands to grass will depend to some extent on how favorable the season is and therefore how good a catch is obtained. The growing of legumes, particularly on the more favored soil areas, should be considered.

It was stated above that the loss of the soil's organic matter increased its tendency to drift. It is logical to suggest then that the soil's fibre content must be maintained if soil drifting is to be controlled. Many different cultural practices have been recommended to control soil drifting. These are well known and have appeared elsewhere in printed form. In this list of practices is included the plowless fallow, strip farming, cover crops and wind breaks, as well as the more emergency practices of listing and the spreading of trash on vulnerable spots. Necessary and advisable as the above control measures are, they still are just control measures and must be supplementary to the systematic maintenance of an adequate supply of organic fibre in the soil. It is of interest to point out here that soil drifting removes the top and hence the most productive portion of the soil. One inch of top removed by erosion means the loss of enough nitrogen to grow 12 to 15 twenty bushel crops of wheat and enough phosphorus to grow about 25 crops. In the brown soil zone of Alberta crested wheat grass is recognized today as the most desirable grass to use to increase the fibre content of the soil.

The light textured soils of this sheet are most likely to drift. Fall sown grains help to control drifting on these light soils by rendering the surface less vulnerable to the high spring winds. These crops have another advantage also, namely, that of making most of their growth during the spring months, which have a higher average rainfall than the summer months. In land of irregular topography there may be a tendency for fall sown crops to winter kill on the knolls and to be spring killed in the flooded areas.

There are many implements in use in western Canada that are designed to help control soil drifting. It should be emphasized that none of these implements has a universal use. What is satisfactory for one soil type may not be for another soil type and what gives satisfactory results one year may not another. They should, however, all kill the weeds and they should leave the land surface as little subject to drifting as possible. That is, as much of the stubble as possible should be kept on top. Implements that pulverize the soil are to be avoided.

The choice of crops that can be successfully grown in this area is limited. It has been primarily a wheat producing area and indications are that it will continue to be a wheat producing area. However, if the productivity of the area is to be maintained, and if present arable lands are not to deteriorate to an unproductive level, then provision must be made to replace some of that which is removed annually by the crops or lost by surface erosion. It does not seem feasible that a straight wheat fallow rotation can be followed indefinitely. The above statements are made with the full realization that the margin of profit is very narrow and that wheat at present is the most profitable dry land crop for this area. However, the continuance of a system of farming that causes a continual deterioration of the natural fertility warrants consideration.

At the beginning of this discussion it was stated that the dark colored soils of this sheet, lying principally on and around Cypress Hills would be treated separately. Due to the higher rainfall in this area, greater yields are obtained and more diversity of crops can be grown here than on the surrounding drier prairie. Wheat and brome grass were the two principal crops grown on the Cypress Hills area and most of the farmers pasture some stock. The valleys are, in the main, quite fertile. The level upper benches, although of good dark colored soil, have a shallow profile, the underlying conglomerate being close to the surface. This prevents the accumulation of any large amounts of subsoil moisture. Soil drifting in this area would be extremely harmful because once the top mantle is lost only conglomerate rock remains. Keeping the soil well supplied with fibre by periodically seeding down to brome grass, is now a common practice in this area. The dark brown soils adjacent to the Sweet Grass hills are on glacial till; where not too rough to cultivate they are good arable lands.

This discussion of farm practice has dealt entirely with dry farming practice. There are no large irrigation blocks in the Milk River sheet and the operating projects are limited to small private spring flooding schemes using spring run-off water. Large areas west of Lake Pakowki have been covered by reconnaissance irrigation surveys but no development has been undertaken.

The two largest spring flood projects are located south of Orion. One lies immediately south of Orion and the other on the flats east of present Lake Pakowki. There are approximately 22,000 acres of level land in these two flats. The larger portion of this area is subject to spring flooding, but only slightly over 3,000 acres have been brought under cultivation.

Pakowki Lake is the centre of an inland drainage system. The water that flows into this land by way of Manyberries, Ketchum, Canal, Coal and other creeks spreads over a large area on reaching the flat. This natural flooding has been assisted by the building of dykes. These dykes spread the water and also hold it back long enough to saturate the soil. This may not be the most efficient method of using the available spring run-off, but it is an inexpensive method and has materially increased the yield on these areas. Wheat is the principal crop grown. On the uncultivated flooded areas western wheat grass is most common. There is also considerable sweet clover that has spread voluntarily over the native hay meadows.

The soil of these irrigated areas are in general heavy, although patches of light textured soils occur, and sandy lenses occur in the profile of the clay areas. (See description of the Soils of the Pakowki flats, page 45.) Alkali has not been a serious problem.

Some small projects have been constructed using water from coulee reservoirs and are particularly valuable in growing winter feed for livestock. In this connection the value of these small projects cannot be over emphasized. Enough irrigation water in a reservoir to water even a garden plot, well repays the effort in the sense of security it affords. A well watered garden is worth much when surrounding crops are suffering for want of rain.

At the beginning of this discussion it was stated that only slightly over one-quarter of the Milk River sheet is cultivated; the remaining three-quarters is used for grazing purposes. The next portion of this discussion will deal with ranching practices in this area.

Prior to 1909 there was little cultivated land in this sheet. Ranches were located wherever water supply was available and stock pastured as far afield as possible from this water supply. As settlement proceeded the ranches were pushed back. Today the largest block of range land lies east of Manyberries, with two smaller areas, one south of Milk River and one along Etzikom coulee south of Skiff. Scattered through the cultivated sections of the sheet, however, are many uncultivated patches and these are being used by the rancher-farmers. Although cattle are most common in the area there is a considerable number of sheep and horses.

Grass, water, winter feed and shelter are four major considerations in the raising of livestock in south-eastern Alberta. Each of these four will be discussed separately.

With the early ranchers overgrazing was not a serious problem. Today, however, due to a combination of economic and natural conditions it has become a problem of first magnitude. The Manyberries Range Station, established in 1927, has demonstrated the need for a conservation programme in the grazing of the grass lands. Overgrazing, it is stated, reduces the pounds of beef produced by a given area. If carried to the point where stock are not able to get an adequate supply of food such things as greater wintering costs and a general trend to stock of smaller stature will result. Overgrazed areas offer little protection to the elements of erosion and little resistance to run-off waters. A hill slope that is overgrazed will not hold the melting snows nor will it hold the water that falls during a quick heavy shower; and these are quite common in this area. In other words the more closely the grass is grazed the less favorable is the soil to grass growth. Overgrazing of light textured areas may permit of soil drifting and the starting of open sand dunes devoid of vegetation. Experiments are being conducted at the Manyberries station and elsewhere to test the practicability of contour furrows and spreader dams. If some of the water that rushes down the valleys during the spring thaw or during a heavy rain could be slowed up and spread over a greater area, more grass would result. Results of these experiments are encouraging. No area should be stocked with more animals than it can reasonably carry over a term of years, and that means maintaining an adequate grass cover at all times. Pasturing an area to capacity during a favorable term of years may be quite disastrous in the following unfavorable years.

A well distributed water supply will help to alleviate overgrazing and at the same time make for a more economical use of the grass available. The Manyberries Range Station state that cattle will not make satisfactory gains in weight if they have over two miles to walk for water. Natural water sources will not adequately meet this requirement. Since the inauguration of the P.F.R.A., encouragement and assistance has been given to the stockmen to provide artificial water supplies in the form of stock-watering dams, or dugouts. There is a large number of available sites for these reservoirs. A large portion of the Milk River sheet is in an artesian basin. This source of water makes an ideal supply for the winter, but the initial cost is rather great to be used to supply the summer range.

Although considerable winter pasturing is possible in this area some extra feed is necessary. The prairie grass is rich in food nutrients and the grass maintains these nutrients in curing. It makes, then, an ideal all-year food. However, the snow may become so deep or it may get so crusted over that stock cannot reach this grass and then winter feeding is necessary. The cereal grains are one of the best sources of a winter feed reserve. This feed reserve, if properly stacked, can be kept for some years with very little loss. Spring or fall rye, wheat, oats, and some cultivated crops, will all give a fair yield (see plate 8, fig. 3). If irrigation is available the cultivated grasses and alfalfa can be grown. Considerable brome grass is being grown on the Cypress plateau for feeding purposes. The rancher-farmer is able to make good use of stubble fields and threshed straw to winter his stock.

All stock need some form of shelter from high winds and blizzards. Sheds, open to the south, have been recommended for the younger stock. For the mature stock, windbreaks, such as board fences, or coulee banks, etc., have been used. There have been times, for example, during the bad storm in the spring of 1938 when cattle smothered behind these temporary protections. Such storms as these occur only rarely, but they may leave tremendous loss in their wake. Longer time weather forecasting would be of great assistance in such cases.

The relative juxtaposition of dry farming lands, range lands, and level areas possible of irrigation development, is very important. The correct development of these lands as well as their inter-relationship is an important problem, the solution of which should tend towards the establishment of a more self-contained community, less liable to the shocks of climatic and other fluctuations.

SOIL RATING MAP

Accompanying this report is a suggested soil rating map of the Milk River sheet on the scale of six miles to the inch. This map divides the area into six land classes: three pasture, and three arable. No attempt has been made to state the type of crop that should be produced on arable land. The map is applicable only under dry land conditions.

The data on this map is based mainly on the physical characteristics of the area. In making the map, such physical data as soil texture, soil color, mode of deposition, the type of soil profile, degree of stoniness, topography, relief, alkali, rainfall, and rainfall variability were all taken into consideration. Each of these factors was given a number value for each soil area, and the multiplying together of these values gave the final index rating of the soil area. With the aid of pasture carrying capacity data and with wheat yield data obtained from government statistics and the Alberta Economic Survey, P.F.R.A., a suggested productivity grouping of these rated areas was obtained. These groups each carry a number and a legend on the map: Group 1 is poor to fair pasture, group 2 is fair to good pasture, group 3 is good to very good pasture, group 4 is poor to fair arable land, group 5 is fair to fairly good arable land, group 6 is fairly good to good arable land. It is realized that this grouping is based on past performance under existing farm practices.

The introduction of more drought resistant varieties of farm crops, the introduction of improved farming methods as well as a change in economic requirements might, for example, shift the dividing line between pasture and arable land. It must also be noted that the number of quarter sections of land necessary to constitute a self-sustaining unit varies from class to class.

It is practically impossible to set any definite productivity limits for these groups. The following tentative limits, however, are suggested to give an approximate idea of the productive capacity of the various groups. Group 1 areas would take over 40 acres to pasture one head of cattle and group 2 areas would take between 20 and 40 acres per head. Group 3 areas would take under 20 acres per head. Group 5 soils over a long term of years have produced from 12 to 15 bushels of wheat per seeded acre and group 6 soils have produced 15 to 20 bushels of wheat per seeded acre. Group 4 soils in general have produced less than 10 to 12 bushels. Some farmers in this sheet have exceeded these limits.

APPENDIX

THE RELATION OF THE GEOLOGY TO THE SOILS IN THE MILK RIVER SHEET

By John A. Allan*

INTRODUCTION

From the geological point of view soils may be regarded as young deposits of Recent or Pleistocene age and are unconsolidated rock. The inorganic part of soil consists of mineral and rock particles which vary in size and shape, but these particles have been derived at some time and in some way from solid rock formations. This unconsolidated mantle of weathered rock material when acted upon by organic agencies and mixed with organic matter may contain the required conditions to support vegetable growth. When rocks are exposed at the surface, various chemical and mechanical agents of erosion act upon the rock surfaces and slowly transform the solid rock into soil. The more soluble constituents in the rock are first affected and the structure of the rock is weakened. The less soluble portions of the rock remain to form the regolith or unconsolidated mantle which may be further broken up by mechanical agents of erosion to produce gravel, sand, clay or silt. If the rock debris produced by weathering is not removed by other agents then the product is residual soil; that is, soil which has been formed in situ from the underlying rock. Soils formed in this way will have some of the physical and mineral characteristics of the underlying rock.

All mineral soils are formed from the decomposition and disintegration of rocks, but all soils are not formed from the rock immediately underlying the soil. There are four major processes in the development of soil; namely, decomposition, disintegration, transportation and deposition.

Most soils have been transported from their original source and become mixed during the process of transportation. The three principal transporting agents are wind, running water and ice in the form of glaciers. However, transported material must eventually come to rest and here the fourth process in the development of soil, namely, deposition, results. The material transported by wind or by glaciers may be deposited on a land surface. Such deposits transported by wind are known as dune, eolian, or some loess deposits. Moraines are deposits left from the melting of glaciers. Water transported material is usually deposited in bodies of water, such as lakes, giving

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rise to lacustrine deposits, swamps as palustrine deposits, and along the margin of river courses as alluvial soils. In water transported deposits there is greater sorting action and the finer particles will be carried farther than the coarser particles. Such deposits might vary from the finest clays and silts, and even colloidal particles, up to the coarsest of gravel. This fact often explains why the texture of a soil may change materially even within the same section of land. During the process of transportation many kinds of rocks become mixed and the soils produced from these transported deposits may be heterogeneous mixtures and of complex mineral composition as, for example, a soil produced from the weathering of an interbedded-sandstone-shale formation will be different from a soil derived from a shale formation, or from shale and granite rock debris, and so on.

There is still another kind of unconsolidated material influenced by water transportation. Rain falling upon any kind of surface deposit such as glacial moraines, residual soils or wind deposits may wash out the finer rock particles and deposit them further down the hillside or on the flats at the bottom of the slopes. These are known as alluvial fans or outwash plains. The character of the soil in these outwash areas might be quite different physically and even chemically from the soil in which the outwash has become deposited.

These introductory notes on the origin of soils are given to make it clear that there is frequently an obvious and close relationship between the kind of soil and even the depth of soil in an area and the geology of the district. There is obviously no sharp line of demarcation in surficial unconsolidated deposits between what may be called soil and what may be called gravel, sand, till or boulder clay. In some parts of Alberta, particularly in the mountains, or in the Precambrian rock area in northeastern Alberta, certain types of vegetation grow on gravel deposits and even in fractures on rock surfaces void of soil. In the latter case the plants derive their food from the decomposed products of minerals in the solid rock. If the rock contains potash-bearing minerals, the rock decay will produce the potassium carbonate which is favorable to plant growth. Other rocks with a phosphate content will support a luxuriant plant growth even though the soil is scarce. However, these finer points in the origin of soil do not enter into a discussion of the geology of the Milk River sheet because rocks of this composition do not occur in this area and there are quite limited areas of solid rock exposed in this map-area. On the other hand the conditions of soil origin as suggested above, occur throughout much of the Milk River sheet.

The entire area of the Milk River sheet has been traversed to obtain geological data but only about two weeks were spent in the field examining the unconsolidated superficial deposits in this map-area. On this account the following notes must not be regarded as a complete geological report on the surficial deposits in Milk River sheet. Some of the more prominent geological features responsible for the distribution of several of the soil types shown on the accompanying map are recorded. 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 interpreted correctly. A correct interpretation of the soil occurrences requires, not only a knowledge of the subsurface geology and structure of the rocks underlying any area, but also the source of the transported soil and the sorting and mixing processes which have occurred since the transported material has been deposited by these agents. It would also require a detailed knowledge of the history of the glacial deposits and the way in which these deposits were formed. This detailed information is not yet available in some parts of the Milk River sheet.

The rock exposures in the Milk River sheet are confined largely to the valley slopes (1) along Milk river in the south of the area, and its numerous small tributaries from the Sweet Grass hills; (2) along the numerous old drainage channels, known as coulées, such as Verdigris, Etzikom, Chin, Fortymile, Seven Persons, Pendant d'Orielle, Lost River and other smaller coulées; and (3) along the southwestern slope of Cypress hills in the northwest corner of the map-area.

PHYSICAL FEATURES

The major physical features and the general character of the surface topography of the surface of Milk River sheet have been adequately described in the earlier part of this report under the heading "Description of Area," and will not be repeated.

The surface topography of any map-area is usually shown by means of contour lines drawn at definite intervals. The contour lines have been omitted from the soil map accompanying this report to avoid confusion in reading the map, but the Geological Survey of Canada in 1940 published the Foremost sheet (Map 566A) and the Dunmore sheet (Map 567A) on a scale of one inch to four miles with contour lines drawn at one hundred foot contour intervals. These maps include the whole of the Milk River sheet and north to the top of township 13. The geology is also shown on these maps, which accompany Memoir 221, Geology of the Southern Alberta Plains by L. S. Russell and R. W. Landes. If fuller details on the surface features of the Milk River sheet are required, reference can be made to the maps cited above.

The Milk River sheet lies entirely within the plains area with an average elevation of 2,800 to 3,000 feet above sea-level. This plain is interrupted only by two prominent uplands, Cypress hills in the northeast corner of the map-area rising to 4,800 feet above sea-level, and the northern slope of Sweet Grass hills of northern Montana with a maximum elevation of about 4,200 feet above sea-level in range 12 on the International Boundary.

The drainage pattern is quite definitely shown on the soil map by the distribution of the eroded areas. The drainage in the Milk River sheet is both pre-Glacial and post-Glacial. Milk river is the major active drainage today, but the size of this valley indicates that it was a more active river at one time. East of the town of Milk River, in range 16, the river meanders through silts until it reaches the bedrock of the upper part of the Milk River formation at the western edge of range 15. East of this point the valley narrows and the river follows a box canyon with craggy sandstone walls over 50 feet high especially east of sec. 2, tp. 2, range 15, where the river has cut into the harder sandstones in the lower part of the Milk River formation. Verdigris coulee enters Milk River valley in range 14 as a hanging valley about 45 feet higher than the river level. The valley of Verdigris, extending northwest to New Dayton, is considerably wider than that of Milk River. This coulee represents a drainage course formed along the front of the retreating ice sheet. Other large coulees, as Etzikom, Chin, etc., have been formed in a similar way along the front of the ice sheet at successive stages in the ice retreat. The soil map accompanying this report shows several narrow and in places canyon-like valleys entering Milk river from the south on the slopes of Sweet Grass hills. The valleys of each of these tributaries are deeply eroded into the solid rock, which forms castellated crags and badland profiles. Deadhorse coulee represents an abandoned river channel and is peculiar in that it opens at both ends into Milk river. On the north side of Milk river the most prominent drainage is Pendant d'Oreille coulee which extends from the river valley in range 8 to Pakowki lake. The south end of this coulee is at least 10 feet higher than the river level and the north end at Pakowki lake is 36 feet lower than Milk river. This indicates that the pre-Glacial valley of Milk river was filled up with glacial deposits and the south end of the coulee was filled in, also the present stream of Milk river was cut in these higher level gravels. East of Pendant d'Oreille coulee, the valley of Milk river is canyon-like about one mile wide and 350 to 450 feet deep as far as range 5 where it crosses the International Boundary into Montana. The sides of this portion of the valley are deeply eroded as is shown on the soil map. There is no doubt that this canyon portion of Milk river valley was cut by a much larger and more active river than the present one. The numerous other abandoned drainage channels on the Milk River sheet all suggest an earlier drainage of large volumes of water, although today the amount of surface water is very small.

Pakowki lake now has inland drainage, but formerly received the drainage from Etzikom coulee, which is an old glacial drainage course. It is possible that Pakowki lake was originally formed when the drainage channels from the lake to Milk river became filled in with rock debris from the melting ice sheet.

In the north part of the Milk River sheet the drainage pattern influenced by the melting ice sheet is seen in Chin, Fortymile, and Seven Persons coulees which drained into the South Saskatchewan river south of Medicine Hat. The size and regular outline of the various coulees suggest that much water was drained from this area since Glacial time.

SUB-SURFACE GEOLOGY

The areal geology of the Milk River sheet is shown on the small scale map (Plate 9) accompanying this report. The geological information shown on this map is compiled from the geological map of Alberta prepared by the writer in 1937, and from maps published by the Geological Survey of Canada in 1940 and compiled by L. S. Russell and R. W. Landes.

The geological formations which occur at the surface or immediately below the unconsolidated deposits in the Milk River sheet are all upper Cretaceous in age, except on top of the Cypress hills in the northeast corner of the map-area where the strata are of Tertiary age.

On the geological map (Plate 9), nine different geological formations are shown. It is not necessary to discuss in detail each of these units, but mention will be made of some of the chief lithological characteristics of each formation. The exposures of these various rocks are limited in area on the Milk River sheet, and are confined largely to the eroded areas shown on the soil map. In other areas on this sheet the information on the rock formations has been obtained only from well records. The rock formations in this map-area, in order of age from the youngest to the oldest, are as follows:

TERTIARY	Cypress Hills	Conglomerate, non-marine, light coloured quartzite boulders held together loosely with finer gravel and sand. Thickness 25 feet in range 3, thickens to east.
	Ravenscrag	Sandstone, massive, crossbedded, buff in colour, fresh-water origin, and about 560 feet thick.
UPPER CRETACEOUS	Whitemud	Clays, 30 feet dark clay overlain by about 17 feet whitish, kaolinized clay in Eagle Butte and west end Cypress hills.
	Eastend (Edmonton)	Sandstone, shale and coal, 440 feet thick in Eagle Butte.
	Bearpaw	Shale, dark coloured with sandy beds, some bentonite, marine. Thickness 830 feet in Eagle Butte and 630 feet near Manyberries.
	Pale Beds (Oldman)	Sandstone and shale, coal seams in uppermost part. Some massive crossbedded buff sandstone. Fresh-water deposition. Thickness 480 feet at Eagle Butte.
	Foremost	Shales, and sandstone with numerous coal seams in upper part. Dark shale and silt with thin coaly beds in lower part. Brackish-water deposition. On Milk river 270 feet thick but thins to east.
	Pakowki	Shales, dark, some sandy beds, marine. Black chert pebbles bed at base. Thickness 500 feet in southeast, thins to west.
	Upper Milk River	Sandstone, argillaceous, sandy shale, lenticular sandstone, streaks of lignite and ironstone. Fresh-water deposition and about 130 feet in thickness.
	Lower Milk River	Sandstone, massive, light-coloured, about 100 feet thick, underlain by about 50 feet shaly sandstone and sandy shale. Fresh-water deposition.
	Alberta	Shale, dark marine with ironstone concretions.

The oldest formation, the *Alberta* shale, is only exposed at one point in the Milk River sheet, on the International Boundary on Deer creek, at the southeast corner sec. 5, tp. 1, range 12.

The Milk River formation is exposed only in the southwestern corner of the map-area along the Milk river valley in tps. 1 and 2, ranges 11 to 15. This formation is divided into two parts which can be readily distinguished in the field. The lower part of the formation consists of harder beds of sandstone and commonly forms castellated cliffs and pinnacles and bizarre outlines on erosion along the sides of the valleys particularly along the Milk river and the mouth of Police coulee. The Writing-on-Stone cliffs south of Masinasin in sec. 35, tp. 1, range 13, are in the lower part of this formation. Figures and various characters have been carved in the massive sandstones. This area where the "writing" occurs is worthy of being made a park reserve. Unfortunately, vandals have disfigured some of these ancient Indian inscriptions. Nodules of pyrite through the sandstone are readily weathered out, leaving grotesque pits and holes in the face of the cliff which extends for about a mile along the valley. Many extraordinary castellated forms of particular scenic beauty occur in sec. 31, tp. 1, range 12. The lower part of this formation disappears at the river level in the northeast corner sec. 33, tp. 1, range 12. In the artesian basin, mapped by D. B. Dowling in 1917 (Geol. Survey Canada, Memoir 93, p. 121), west of Pakowki lake and south of Chin coulee, water is obtained from sandstones in the lower part of the *Milk River* formation.

The dark coloured *Pakowki* marine shales occur at the surface, marginal to the underlying formation, along the north side of Milk river valley from Verdigris coulee east to Pendant d'Oreille coulee in range 11. This shale formation has not had much direct influence on the soil types, except possibly in local areas such as the fine sandy loam in tp. 2, range 11, and the clay along Pendant d'Oreille coulee in range 8. The shale debris has been intermixed with the glacial till. In general the soils in the west half of the map-area have been developed in sorted and unsorted glacial till.

The non-marine *Foremost* formation consisting of soft sandstones and shales underlies about two-thirds of the Milk River sheet west of range 7 and north of tp. 2, also in tp. 1, ranges 9 and 10. In all about 50 townships are underlain by this formation, beneath the unconsolidated mantle of glacial till. The debris from these rocks is reddish to yellowish in colour. There are numerous coal seams in this formation and many beds of brackish-water molluscs. This is an important coal-bearing formation. In this map-area small quantities of coal have been mined by open pits on Fortymile coulee in secs. 1 and 12, tp. 8, range 11, at several places on Seven Persons and Chin coulees, near Comrey and at many other points. The coal is lignite in rank. It is quite possible that much of the heavy loam, the silt loam and clay loam in the western half of this map-area has been influenced by this formation which has been worked over by the ice sheet.

The term *Oldman* formation has been proposed by L. S. Russell to replace the term *Pale Beds* which is the highest member in the *Belly River* group. This formation outcrops in the map-area usually as extensive badlands along both sides of the valley of Milk river from range 7 eastward and especially along Lost river from the International Boundary northwest to the escarpment north of Comrey. Numerous patches of badlands occur on Sage creek and Cripple creek. The upper beds in the formation occur around Manyberries and to the northwest where it outcrops west of Bulleshead Butte in sec. 11, tp. 8, range 7. This formation also occurs between Fortymile and Seven Persons coulees in tps. 7 and 8. The strata in this formation consist chiefly of soft light coloured shales and sandstones, but clays or clayey shales predominate. The coarser sandstones are commonly crossbedded, indicating shallow water deposition. Near the top of the formation there are thin coal seams and coaly shales. The soft character of the shales and sandstones in both the *Oldman* and *Foremost* formations have influenced to a marked degree the types of soils in this area. These strata have been easily disintegrated by the advancing ice sheets, and weathered by the water from the melting ice. These two formations have a combined thickness of about 750 feet in this map-area. The upper part of the *Oldman* has been called the *Lethbridge coal member*. It contains thin coal seams and some thin bentonite beds. Some coal has been removed by open pit in sections 2 and 15, tp. 5, range 5, but there is no coal mining in these thin seams in this map-area.

The *Bearpaw* formation consists almost entirely of dark shales of marine deposition. This formation occurs under the unconsolidated mantle as a belt from the east side of Milk River sheet, which is the Alberta-Saskatchewan boundary in tps. 3, 4, 5 and 6, extending in a northwesterly trend to tp. 8, ranges 4, 5 and 6, bounding the Cypress hills on the south and west. There are numerous outcrops of these shales as badlands east of Manyberries on the headwaters of Manyberries and Sage creeks and also northeast of Bullshead Butte. There are many thin beds of bentonite interstratified with the shales. This bentonite makes the clays derived from this formation heavy. This formation has influenced the distribution of the clay loams along the eastern side of the map-area in tps. 4, 5 and 6, ranges 1 and 2. A large exposure of these shales was examined on Willow creek 4 miles south of Thelma postoffice in sec. 23, tp. 6, range 3. On this exposure the dark coloured shales are traversed by a number of steep-dipping "sandstone dikes", less than one foot in width and pinching out downwards. These "dikes" consist of sand grains held together by gypsum. They have been formed by downward moving solutions from the overlying *Eastend* (Edmonton) sandy beds.

The term *Eastend* formation was proposed by L. S. Russell for the beds above the *Bearpaw* and below the *Whitemud* formation. The *Eastend* is correlated with the *Edmonton* formation to the north and the *St. Mary River* formation to the west. In this map-area this formation is well exposed on the creek south of Thelma at the southwest end of Cypress hills in tp. 7, range 3. Another section was examined in SE ¼ sec. 7, tp. 8, range 3, north of the road at the extreme west end of

Cypress hills where the formation is about 325 feet thick consisting of soft crossbedded sandstone overlain by about 100 feet of soft shale that breaks down readily, thin massive sandstone with shales, and a thick coal seam which is mined at Elkwater lake on the north side of the hills and at Thelma on the south slope. This formation occurs as a narrow band around the top of Cypress hills which is capped by Tertiary strata. The Eastend (Edmonton) also occurs as an island west of Lodge creek and forming Eagle Butte hills. This formation which occurs on the steep upper slopes of Cypress hills has influenced the soil types immediately lower on the slopes, as sorted residual or sorted by glacial action. Cypress hills is an erosional residual, and erosion has been largely by ice.

The *Whitemud* formation has not been shown on the geological map (Plate 9) because the areas where it occurs are small. The formation is only about 50 feet thick but it contains a very prominent bed of whitish clay that makes a good geological marker and which contains a one-foot bed of highly refractory clay. There is a hard light coloured stratum, about 6 inches thick, near the top which is believed to be of volcanic origin. This thin series outcrops near the top of the escarpment on the west end of Cypress hills, both to the east and west of Fly lake, and as four small islands fringing Tertiary beds on the top of Eagle Butte hills.

The Tertiary strata cap the Cypress hills and underlie about 150 sections in tps. 7 and 8, ranges 1, 2 and 3. The underlying *Ravenscrag* formation about 560 feet thick, consists chiefly of massive crossbedded sandstone forming the prominent escarpment round the west end of Cypress hills. West of Lodge creek there are four small outliers on the hills about Eagle Butte. The sands from this formation are distributed through the soil types farther down the slopes of Cypress hills.

The *Cypress Hills* formation overlies the *Ravenscrag*, and caps the entire surface of Cypress hills. In sec. 10, tp. 8, range 3, at the west end of Cypress hills, this formation consists of about 35 feet of conglomerate made up of light coloured quartzite boulders held together by sand, clay and some fine gravel. One hard bed forms a vertical escarpment at the edge of the plateau. The soil on the top of Cypress hills is residual and there is no glacial debris on this flat surface. Gravel and boulders from this formation are scattered down the flanks of Cypress hills especially on the south side where there are gravels and stones in the soil types. The age of this formation is considered to be early Oligocene and is the youngest formation recognized in Alberta. The conglomerates on the top of Handhills east of Drumheller, and those on top of Swan hills south of Lesser Slave lake are considered to be of the same age.

Two miles north and one mile east of Manyberries in SW ¼ sec. 5, tp. 6, range 3, the writer observed two small outcrops of a soft clayey crossbedded sandstone on the side of Manyberries creek. This rock possibly represents an inter-glacial deposit, but L. S. Russell has suggested, on lack of other evidence, that it is possibly of Pliocene origin. If this is the case, then it would be the youngest rock formation in Alberta.

ORIGIN OF SURFICIAL DEPOSITS IN MILK RIVER SHEET

It is not always possible to determine the origin of the surface deposits in certain areas, because frequently the unconsolidated material is of mixed origin. This is particularly true in the case of reworked deposits such as outwash plains, alluvial, and marginal 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, bth vegetable and animal, has caused tho soils, particularly the surface soils, to assume a dark color. In most cases the surface leaching has deprived the soils of certain original minerals, and often the mineral content of the subsoils has been changed.

The general character of the surface of the Milk River sheet indicates to some degree the character and distribution of the unconsolidated deposits. This is shown in Table V, Part 1, on page 35 and also on the accompanying soil map. Approximately 11 percent of the Milk River sheet is represented by eroded areas and much of this area is on bedrock exposures. Over two-thirds of the map-area has a level to gently rolling surface in which the unconsolidated deposits consist largely of alluvial, residual or well sorted glacial moraine. The hilly areas represent only 7 percent, and these include Cypress hills in the northeast corner of the map and that portion of Alberta chiefly in township 1, south of Milk river on the slopes of Sweet Grass hills in northern Montana. The definitely rolling areas, that represent the deeper morainal ridges, occupy 12.1 percent of the map-area. The lack of surface moisture in the southeastern part of Alberta is shown by 1.4 percent of lakes and marshes. On the other hand, the geological history and the number of large well defined coulees and abandoned channels indicate a drainage pattern adapted to transport large volumes of surface water in comparatively recent geological time.

With the exception of Pakowki lake basin there are no large post-Glacial, inter-Glacial or pre-Glacial lake basins in evidence in the Milk River sheet. There is a wide distribution of alluvial soils, residual soils and ground moraines that have been more or less extensively reworked in some places by the action of running water. In general the soils south of a line from Cypress hills, Manyberries and Pakowki to the International Boundary, and a strip to the west along both sides of Milk river are mapped as residual, sorted residual and glacial residual. This soil has been influenced by the parent rock which is usually close to the surface. It has not been possible to classify as to origin all types of surface deposits in the time available in the field for this investigation.

The unconsolidated surface deposits in the Milk River sheet can be classified under four major types:

(1) Residual.
(2) Glacial moraine, unsorted.
(3) Resorted glacial deposits.
(4) Transported deposits of alluvial, lacustrine and dune or eolian origin.

The first type includes the residual soils formed by erosion processes from the underlying rock formation. Soil formed in this way will have a composition somewhat similar to the composition of the underlying rock from which the soil has been formed. More frequently the residual soils have been resorted or affected in some way by various transporting agents of erosion and in such cases the composition of the soil is not similar to that of the underlying strata.

In Milk River sheet the areas of residual soil that have not been partly sorted by later erosion are irregularly distributed along the north side and west end of Cypress hills and southwest to Manyberries creek, and also along the International Boundary in tp. 1, ranges 4, 5, and 6. In this same part of the map-area there is a wide distribution of residual soils that form a large part of the glacial till and ground moraine. There are also irregular areas of sorted residual soils, some sorted by moving water, extending along the south border of the map-area, on both sides of Milk river valley and in townships 1 and 2 from Sage creek in range 2 west to range 13 in the vicinity of Masinasin and north into township 3. Some of these soils have in places been moved along the old drainage channels. Some of the changes that may be recognized in the composition of these soils are due to the different kind of upper Cretaceous strata from which the residual soil has been derived.

The second major type includes those deposits of glacial origin which occur in the form of ridges of terminal, or a ground moraine usually thin or represented by scattered glacial boulders and pebbles. The glacial deposits may consist of till which is glacial debris without boulders. In morainal ridges there may be much coarse material.

The glacial deposits in this part of Alberta have been transported by Keewatin glacial ice during the Ice Age from the northeast. Some of the boulders and pebbles have been carried from the Precambrian areas in the vicinity of Hudson Bay. When the ice melted, the gravel, sand and clay deposits were left over the surface. If the ice front remained in one position for a longer time, a terminal moraine was formed consisting of an unsorted "dump" of till or boulder clay. If the ice front retreated steadily, a ground moraine was left over the surface. During the thousands of years that have elapsed since the glaciers melted in this part of Alberta, erosion agents in various forms, such as running water, or wind, have resorted or washed over the slopes on the moraines and removed the finer materials to lower levels. Glacial deposits which have not been affected by water or wind can be recognized by the presence of unstratified boulder clay or till without many pebbles and boulders. When stratification or evidence of sorting occurs in the glacial deposit the material would be classed in the third type, namely, resorted glacial deposits.

It has already been pointed out that the rocks underlying the Milk River sheet are mainly relatively soft sandstones, shales and coal seams of upper Cretaceous age, all of which are easily eroded by the movement of glaciers. A large amount of the glacial debris in this map-area has been derived from these upper Cretaceous strata. There may be glacial erratics and smaller boulders and gravel from distant points, but most of the glacial deposits in this southeastern part of Alberta have been derived from the underlying or subjacent formations over which the ice has passed in the close proximity of the deposit. In the Milk River sheet much of the glacial materials has not been transported more than a few miles from the parent rock.

There is a wide distribution of glacial deposits in this map-area and it is not always possible to distinguish the glacial from the residual material. There are several low morainal ridges sub-parallel to many of the coulees that represent drainage courses formed at different stages along the front of the retreating ice sheet. One of these morainal ridges extends along the north side of Etzikom coulee. Other similar ridges occur east of Lucky Strike, along Pendant d'Oreille coulee, in range 1 south of Lodge creek, and at a number of other localities. Thick morainal deposits are not common. The thickest till deposits observed are along Peigan creek in tp. 7, ranges 7 and 8, where the till ranges from 30 to 50 feet in thickness. Glacial erratics that have been transported long distances are rare. I observed a few boulders of Presqu'ile dolomite east of the Lucky Strike plain in sec. 33, tp. 3, range 11. These boulders have been transported by ice from the vicinity of Great Slave lake about 850 miles north of their present position.

There are several small areas of the third type, namely, resorted glacial deposits shown on the Milk River sheet. Well sorted and varved clays, indicating seasonal deposition, were observed at a number of places. In a railway cut close to Manyberries station, the till is exposed to a depth of 18 feet, and the upper part is distinctly varved.

The fourth type of surface material includes the transported deposits. The transporting agents are wind and running water, either along stream courses or as run-off. The former gives rise to dunes or eolian plains, the latter to alluvial, flood plain and lacustrine deposits. Transported soils are bedded in character due to the sorting action of the transporting agents. The sand and clay may occur in separate layers or lenses, forming a sandy soil or a clay soil. These deposits may be a mixture of sand and clay with varying proportions of each, giving rise to a sandy clay or a clay loam or a sandy loam soil. It is not always possible to distinguishe the fourth type, that is the transported deposits of recent origin, from the resorted or transported glacial deposits.

The true alluvial deposits consist of well sorted clay, silt, sand or gravel that have been transported and deposited in running water. The most recent alluvial deposits occur along the bottoms of drainage courses. Older alluvial deposits occur as terraces along the sides of drainage channels, or in some places in the upland plains where sediments were deposited before the present drainage pattern was developed. In the Milk River sheet fluviatile deposits are mapped along the floors of the valleys such as Milk river, Verdigris, Etzikom, Chin, Fortymile, Seven Persons coulees, Coal, Canal, Lodge and other creeks. Older alluvial terraces occur marginal to Milk river. Alluvial plains occur west of Seven Persons coulee, near Crow Indian lake, and at several other places close to some of the coulees.

The true lacustrine deposits are represented in this map-area, but with the exception of Pakowki lake basin, all the others are small. Pakowki lake was formerly considerably larger than it is today. The lacustrine beds extend south along Pendant d'Oreille coulee to Milk river, southeast up Canal and Ketchum creeks, north through the centre of range 7, by Fourways to Peigan creek, and another former arm of the lake extended north between ranges 7 and 8 across Peigan creek to the centre of township 8 where this arm of the lake deposits turns sharply to the west and enters Seven Persons coulee in sec. 28, tp. 8, range 8. There is a smaller lake basin at the southeast corner of the map north of Wildhorse mostly within tp. 1, range 2. This basin is an extension of the present Milk River lake. The lacustrine deposits in this basin were derived chiefly from the underlying Oldman (Pale Beds) formation.

Eolian deposits may be found on any kind of fine textured soils. There are many small dune areas in the Milk River sheet. One of the most prominent dune areas occurs around the north and east sides of Pakowki lake in tp. 5, range 7, and the east side of range 8. This dune sand has been derived mainly from the underlying sandstones in the Foremost formation.

The "blowout" areas do not seem to be directly related to the parent rock. There is one "blowout" over the *Bearpaw* shales in tp. 8 at the east side of range 7, and six miles west there is another "blowout" in the fine lacustrine clays.

ARTESIAN WATER

An artesian water basin was discovered in 1915 by D. B. Dowling of the Geological Survey of Canada. This artesian basin lies between Milk river and the South Saskatchewan river, and from the vicinity of Pakowki lake in range 6 west to the vicinity of Skiff and Taber. In general the northwest part of Milk River sheet lies within the basin. In 1916 the Federal Government drilled three wells to test the geological conclusions with reference to artesian water. The results were satisfactory. One well produced 4,000 gallons a day, a second produced 11,000 gallons and the third produced 30,000 gallons per day. Today there are approximately 100 artesian wells within this basin. A table is given below showing the location of each well and the depth to the water-bearing sandstone within the Milk River sheet, as recorded by Dowling in G.S.C. Summ. Rept., Part B, 1922.

In this artesian basin the strata rise in three directions, to the Cypress hills on the east, to the Sweet Grass hills on the south and to the Milk river ridge on the west.

It is the sandstones in the lower part of the Milk River formation in which the artesian water is found. The water enters a permeable sandstone where it is cut by the Milk river especially between Milk River station and Deadhorse coulee, chiefly in ranges 12 to 15. This sandstone is overlain by an impervious shale which prevents the water from seeping to the surface. The water moves down through this porous sandstone to the northeast. The water continues down the bed of sandstone until it reaches the natural gas in the same stratum, and until the pressure exerted by the gas will prevent the water from travelling further to the north. The water in the aquifer, that is, the water-bearing sandstone, is under pressure depending upon the height of the source of supply which is the Milk river, where the lower part of the Milk river formation comes to the surface. If a well is drilled into the water-bearing sandstone it will rise to this source level. If the surface level at the well is lower than the source of supply then water will flow from the well and will be an artesian well.

The depth to the water-bearing sandstone in this map-area, as shown in the last column of the accompanying table, varies with the location, from 490 feet to 895 feet.

In many of the artesian wells and water wells a quantity of gas came out with the water. In some cases both gas and water are utilized from the one well. The water contains some soluble salts, sodium chloride and sodium carbonate. The soluble salts content which is not large appears to increase slightly to the north. The water is quite soft, and the slight taste is not detrimental for domestic or stock usage. When used for irrigation there is a danger of an accumulation of carbonate of soda in the soil.

Beyond the limits of the artesian basin water can usually be obtained by pumping from sandstone beds or in some parts from gravels and sands of glacial or alluvial origin.

ARTESIAN WELLS IN LOWER PART MILK RIVER FORMATION
Listed in Geol. Surv. Can., Summ. Rept., Part B, 1922

Sec.	Tp.	R.	Elev.	Depth to sands
SW ¼ 7	4	6	2,853	637
NW ¼ 9	3	7	2,891	654
NE ¼ 32	4	7	2,811	616(1)
35	4	7	2,836	640
36	4	7	2,846	694
E. ½ 11	5	7	2,830	717
2	5	7	2,836	665
19-30	4	8	2,919	620
NW ¼ 30	8	8	2,711	740
NW ¼ 21	4	9	2,998	680
14	6	9	2,893	718
NE ¼ 19	7	9	2,803	714
W. ½ 20	7	9	2,803	736
SW ¼ 31	5	10	2,859	532
16	6	10	2,900	762
NE ¼ 7	7	10	2,833	677
SW ¼ 15	7	10	2,843	665
S. ½ 25	7	10	2,813	714
26	7	10	2,858	712
S. ½ 28	7	10	2,813	685
W. ½ 32	7	10	2,823	650
5	8	10	2,823	700
S. ½ 6	8	10	2,833	684
W. ½ 6	8	10	2,833	707
NW ¼ 7	8	10	2,806	726
N. ½ 20	8	10	2,811	780
E. ½ 29	8	10	2,796	765

Sec.	Tp.	R.	Elev.	Depth to sands
24	2	11	2,903	167
28	3	11	3,167	510(2)
SW ¼ 8	4	11	3,159	508(2)
1	6	11	3,004	
SW ¼ 4	6	11	2,967	708
NW ¼ 9	6	11	2,940	690
SW ¼ 13	6	11	2,997(3)	
16	6	11	2,922	650
NW ¼ 33	6	11	2,853	625
SW ¼ 2	7	11	2,853	650
NW ¼ 2	7	11	2,843	640
SW ¼ 4	7	11	2,833	
SW ¼ 14	7	11	2,800	646
S. ½ 15	7	11	2,800	646
SE ¼ 18	7	11	2,816	
SE ¼ 20	7	11	2,776	650
N. ½ 20	7	11	2,731	
21	7	11	2,776	640
SW ¼ 24	7	11	2,803	625
E. ½ 2	8	11	2,775	
NE ¼ 7	8	11	2,730	600
NW ¼ 9	8	11	2,740	630
W. ½ 15	8	11	2,760	650
LSD 4 23	8	11	2,621	490
30	8	11	2,714	637
33	8	11	2,705	665
36	6	12	2,656	
NE ¼ 3	8	12	2,770	640
N. ½ 10	8	12	2,753	620
NE ¼ 20	8	12	2,743	650
NE ¼ 33	8	12	2,703	640
30	5	13	3,035	630(4)
1	7	13	2,660	350
8	7	13		
NW ¼ 15	7	13	2,906	680
4	8	13	2,831	650
10	8	13	2,800	655
11-12	8	13	2,781	630
15	8	13	2,771	640
22	8	13	2,751	602
SE ¼ 30	8	13	2,791	652
SE ¼ 31	8	13	2,765	642
SE ¼ 33	8	13	2,720	630
34	5	14	3,027	610
26	6	14	2,957	683
SW ¼ 24	8	14	2,841	735
21	7	15	2,713	503
36	8	15	2,833	895(5)

NOTE:

(1) With gas.
(2) Water does not reach surface.
(3) Water pumped from 2,982 feet.
(4) Water rises to 72 feet from surface.
(5) Chiefly gas.