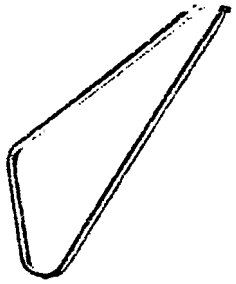

Alberta Research Council
Open File Report 1974-37

MARL RESOURCES OF THE PEACE RIVER AREA

M. E. Holter

Alberta
RESEARCH COUNCIL

Introduction

Several areas of Alberta contain acidic soils which limit the agricultural potential in terms of production of such crops as alfalfa, sweet clover, rapeseed and barley. For this reason the Alberta Department of Agriculture sought the assistance of the Earth Sciences Division of Alberta Research in an effort to delineate favorably located reserves of natural calcareous materials for treatment of such soils. The Peace River area (shown in Fig. 1, in relationship to acid soil regions) was regarded as a major area for study and, as a result, a preliminary contact was made by Mr. Doug Penny of the Department of Agriculture with Mr. Orest Tokarsky of the Groundwater Division of Alberta Research to determine specific possibilities for investigation of calcareous deposits. Mr. Tokarsky compiled a list of locations of occurrences of marl* of which one (the Grimshaw deposit) is within the area of interest. Mr. Penny later became aware of two additional occurrences; one south of Demmitt and the other near Spirit River.

The writer learned of a fourth deposit (Bay Tree) through scanning of limestone leases on file with the Alberta Department of Mines and Minerals. Mr. Arnold Hennig of the Canada Department of Agriculture Station at Beaverlodge also had prior knowledge of the Demmitt and Bay Tree sites. Recently, the writer was informed of another deposit near Spirit River by Mr. Doug Hackbarth of the Groundwater Division, Alberta Research. The occurrences of the four deposits investigated are shown in figure 2.

Each of the sites were visited during October, 1973 by a party composed of Mr. Penny, Mr. Hennig and the writer. A number of shallow test holes were dug utilizing a 2-inch diameter Eykelkamp hand auger which proved extremely successful as a light, rapid and accurate sampling tool for the marl.

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*Defined as a calcareous clay, or an intimate mixture of clay and particles of calcite or dolomite, commonly fragments of shells. The percentage of calcium or magnesium carbonate may range from greater than 90 to less than 30 percent and the name does not usually connote any particular composition. For purposes of this report unconsolidated materials containing greater than 10 percent calcium or magnesium carbonate are classified as marls.

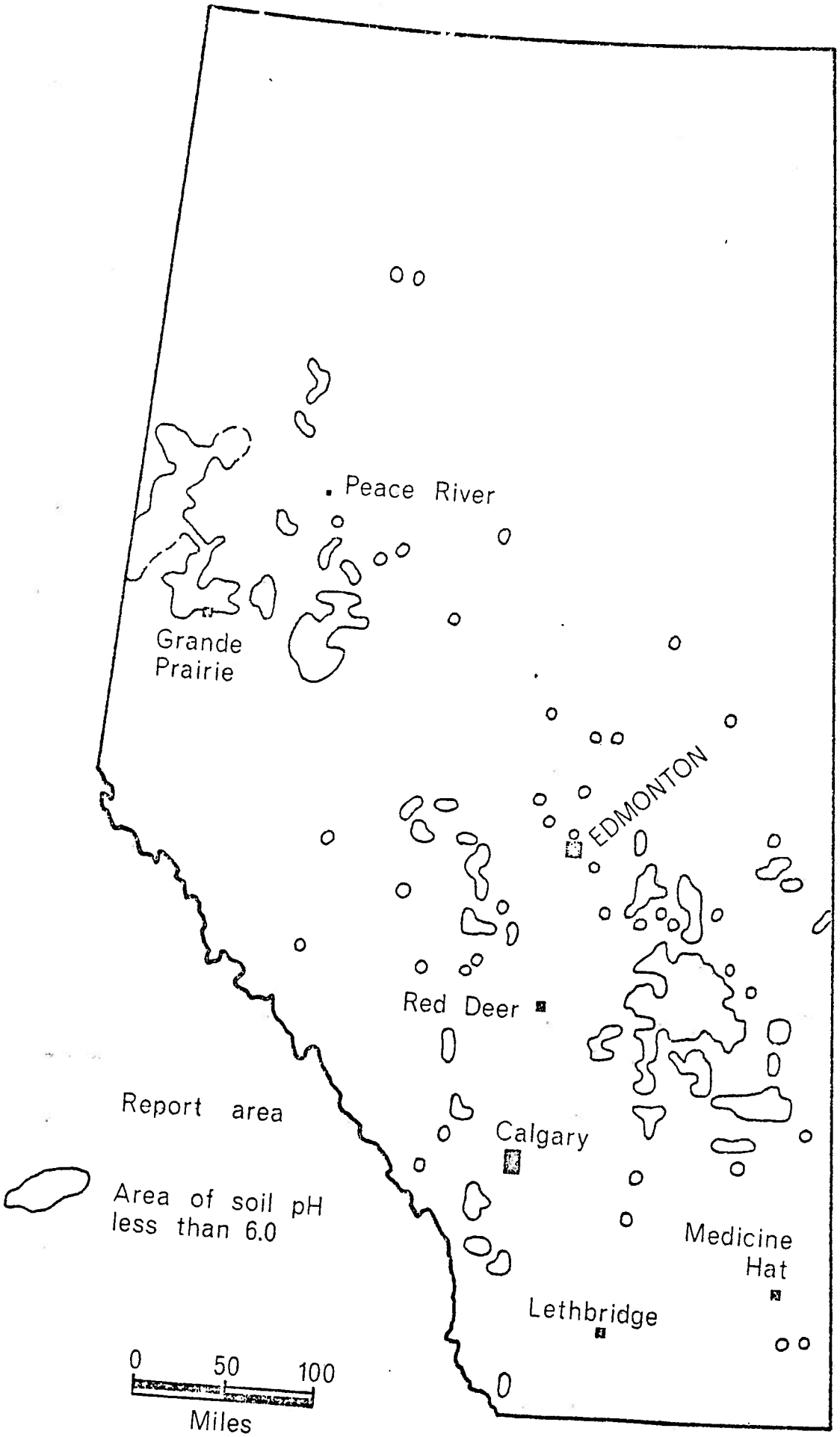


Figure 1. Acid Soil Areas o Alberta

1. Demmitt Deposit
2. Bay Tree Deposit
3. Spirit River Deposit
4. Grimshaw Deposit

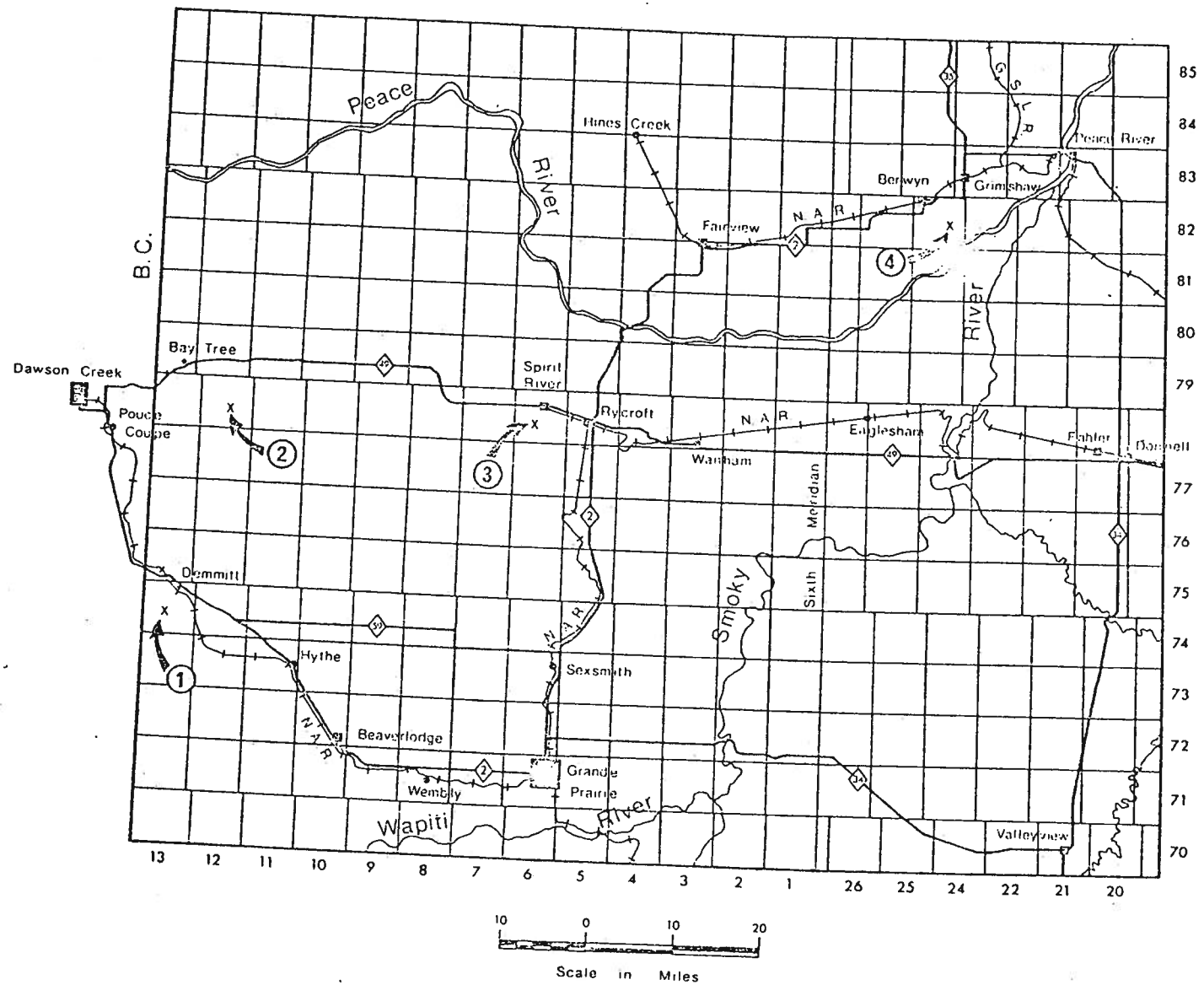


Figure 2. Location Map.

Demmitt Deposit

The Demmitt marl deposit (see Fig. 3 for location) was originally discovered by homesteaders who unearthed marl along a wagon trail used to haul hay from meadows southwest of the village. A small, shallow pit was excavated and the material was locally used for white-washing and chicken grit. Mr. Francis Ramsden of Wembley "rediscovered" the deposit during the winter of 1972 - 1973 with the assistance of a local farmer. Mr. Ramsden informed Mr. Hennig and Mr. Penny of his find and greatly assisted in directing these men and the writer to the site.

The deposit occurs in Lsd. 10, Sec. 16, Tp. 74, Rge. 16, W.6M and may be located on the 1:50,000 scale (approximately 1 inch equals 1 mile) topographic map entitled "Hythe 83M/5 West" published by the Department of Mines and Technical Surveys, Ottawa and on air photos YC 354-5510-104 and YC 354-5510-105. Both the topographic map and air photo stereo pair are available from the Alberta Department of Lands and Forests, Technical Division, Natural Resources Building, Edmonton.

The site may be reached by travelling 1.65 miles south of Demmitt and thence one mile west. From this point a cut line is followed 1.15 miles south to intersect the wagon trail which proceeds approximately 0.55 miles to the site. Both the cut line and wagon trail were made impassable for normal vehicular traffic after heavy snows during the autumn of 1973 felled numerous trees across both routes. The wagon trail is particularly difficult to travel and is more obvious as a tangle of fallen vegetation than as a means of access.

The marl is situated on a well-wooded, gentle side slope adjacent to a small stream and it appears to be less than a few hundred feet in diameter. It occurs beneath 6 inches to 1 foot of organic cover and extends to as much as 4 feet in depth. The material beneath the marl is a fine, calcareous sand at the pit site. Figures 5 and 6 provide details of the lithology and analyses (Fig. 4 may be referred to as the legend for the figures). The color of the dry marl is light grey (Table I) and the moisture

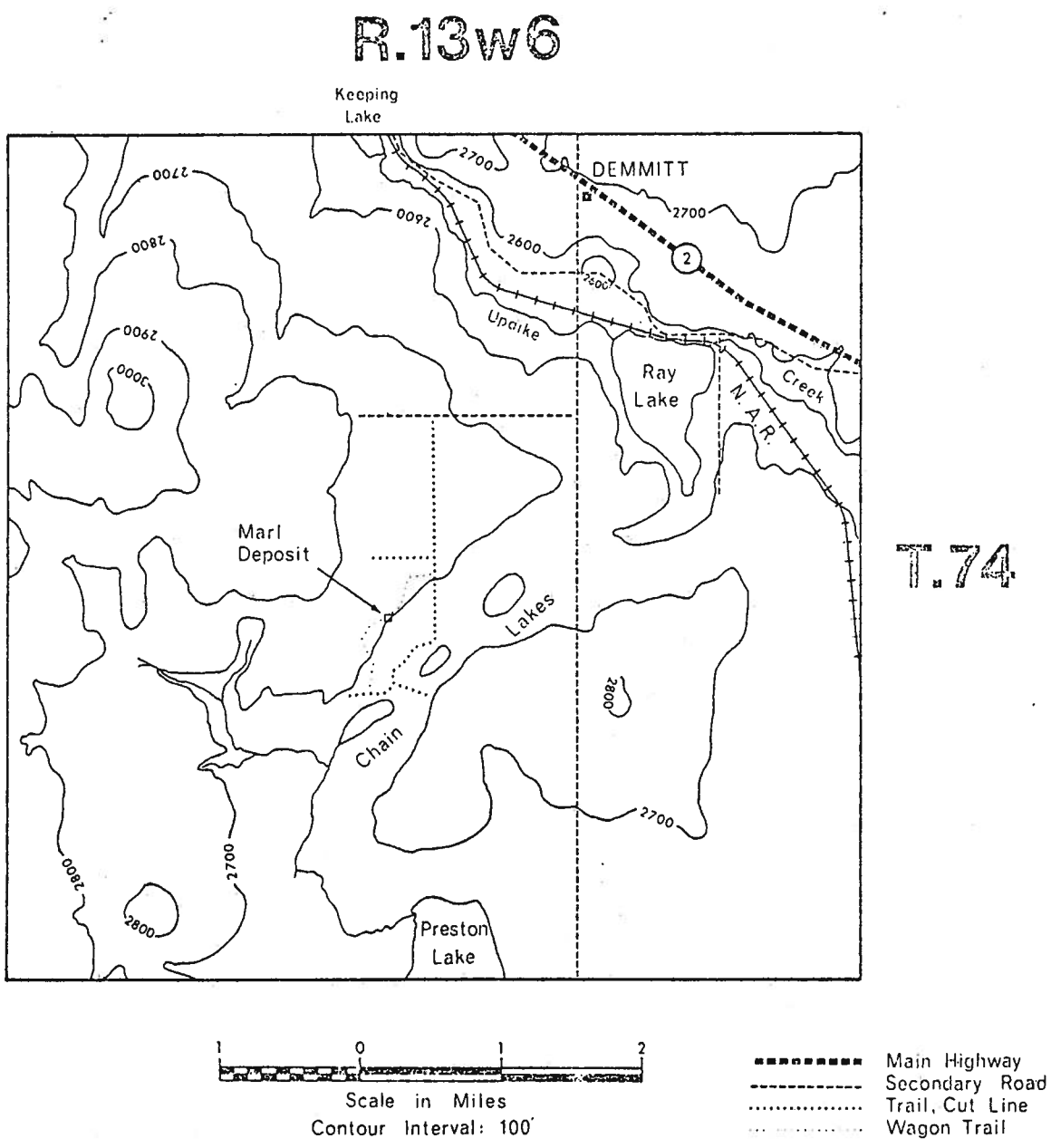


Figure 3. Location Map of the Demmitt Area.

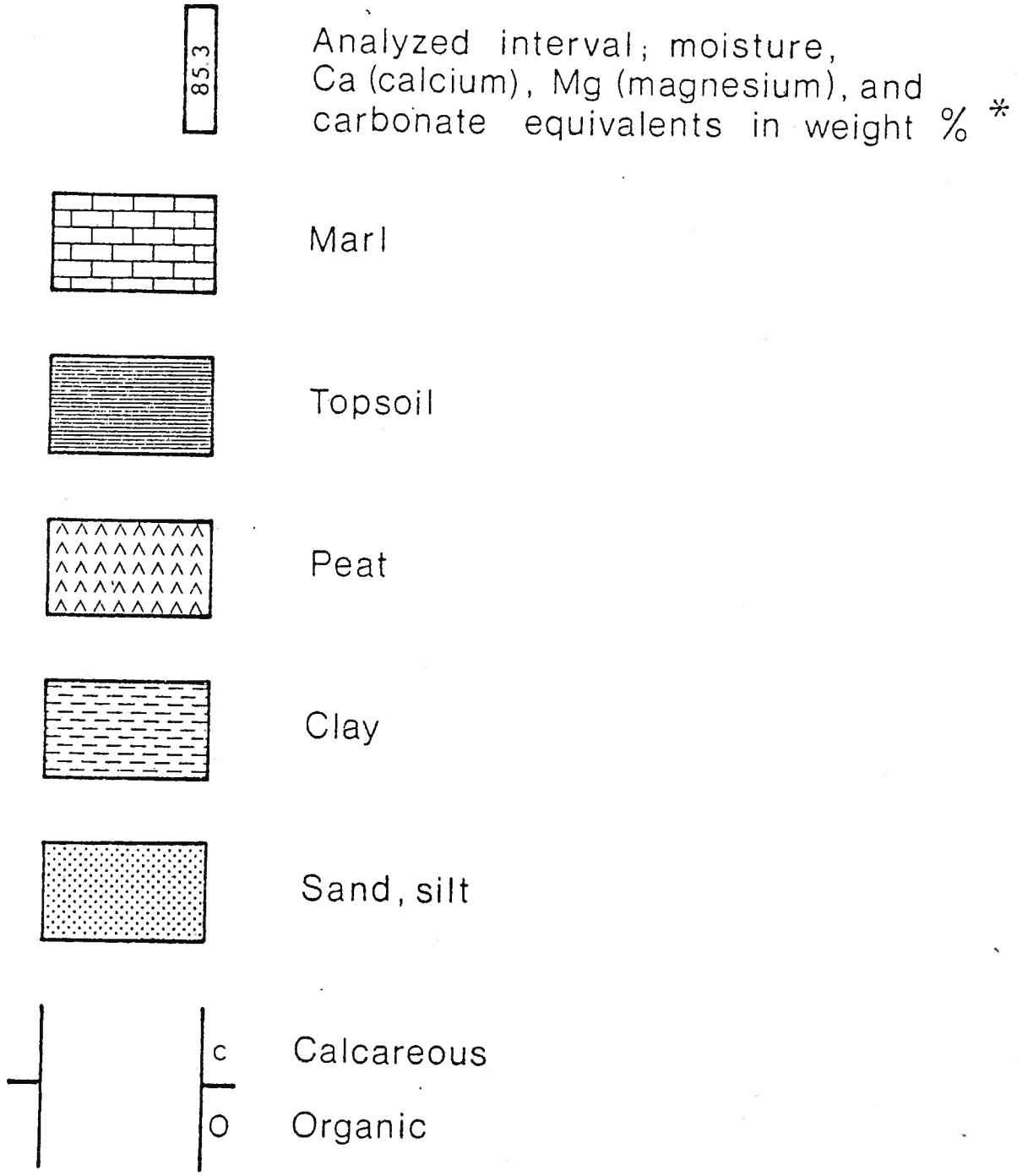
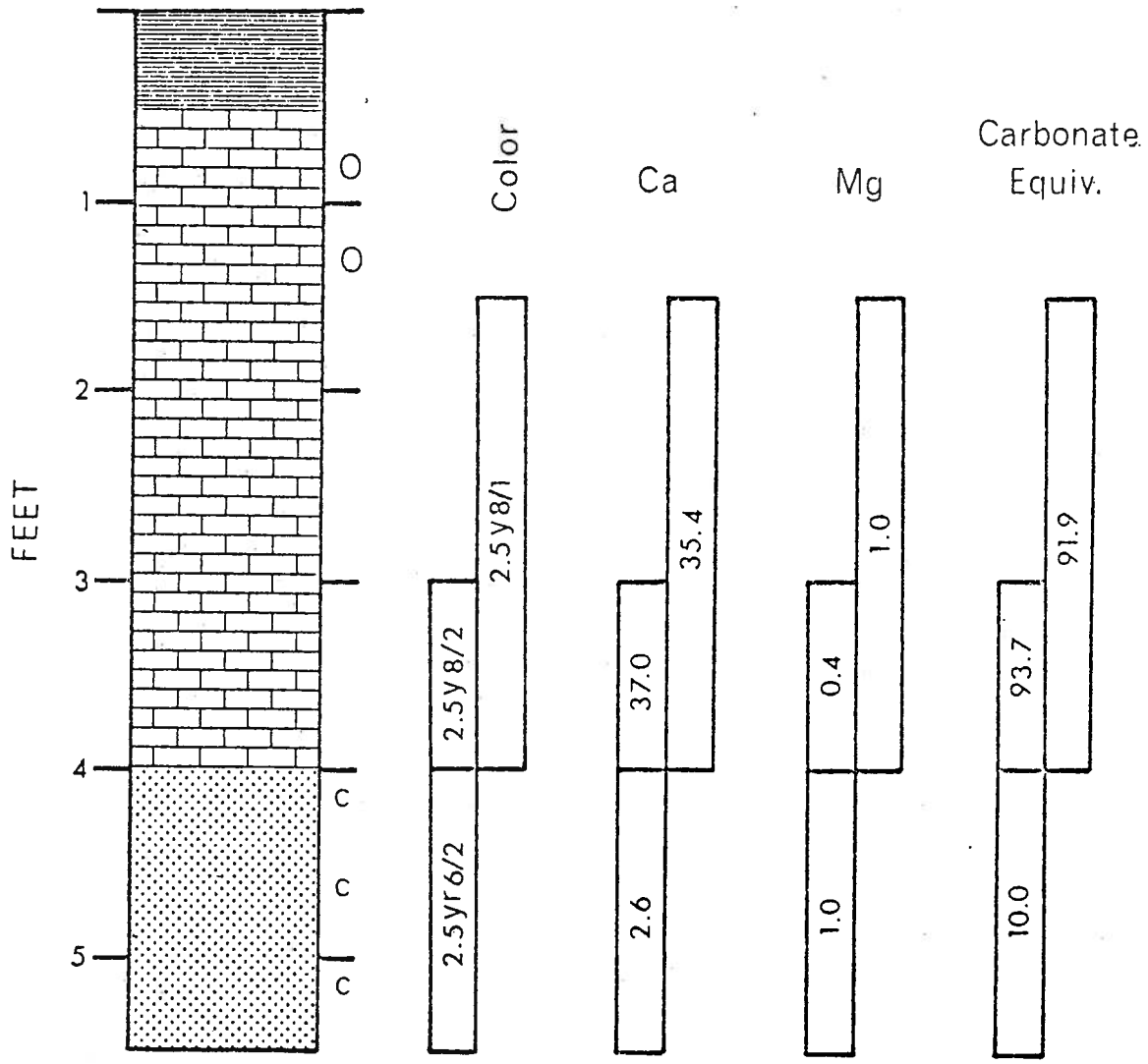
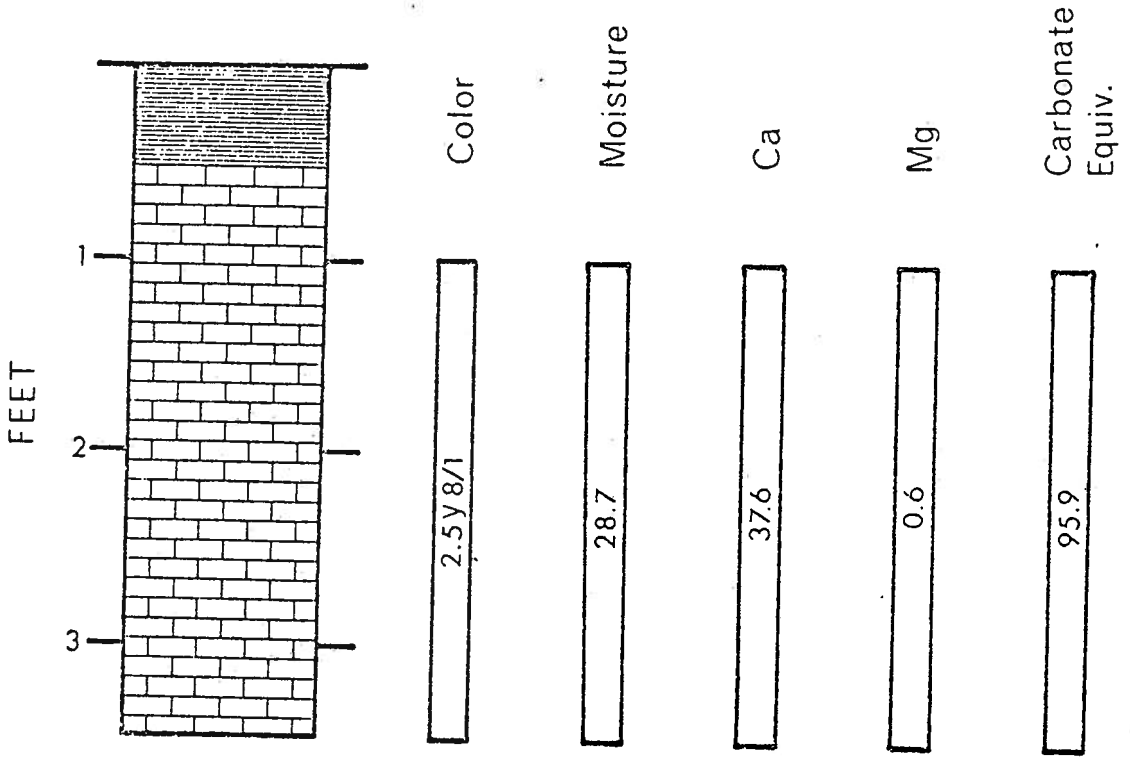


Figure 4. Legend for Test Hole Sections.



Demmitt Pit

Figure 5.



Demmitt Deposit, Hole 1

Figure 6.

Table I. Selected Munsell Color Standards

Code	Description
2.5Y 3/2	brownish black
2.5Y 4/1	yellowish grey
2.5Y 4/1.5	dark yellowish grey to dark greyish yellow
2.5Y 5/1	yellowish grey
2.5Y 5/2	dark greyish yellow
2.5Y 6/1	yellowish grey
2.5Y 6/2	greyish yellow
2.5Y 6/3	dull yellow
2.5Y 6/4	dull yellow
2.5Y 7/1	light grey
2.5Y 7/2	greyish yellow
2.5Y 7/3	light yellow
2.5Y 8/1	light grey
2.5Y 8/2	light grey
2.5YR 6/2	greyish red
5Y 4/1	grey
5Y 5/1	grey
5Y 6/1	grey
5YR 6/3	dull orange
5YR 8/2	light grey
7.5Y 4/1	grey
7.5Y 5/1	grey
7.5YR 4/2	greyish brown
7.5YR 5/2	greyish brown
7.5YR 6/1	brownish grey
7.5YR 6/1.5	brownish grey
7.5YR 7/1	light brownish grey
7.5YR 7/2	light brownish grey
7.5YR 8/1	light grey
10Y 2/1	black
10Y 4/1	grey
10Y 6/1	grey
10YR 4/2	greyish yellow brown
10YR 5/1	brownish grey
10YR 6/1	brownish grey
10YR 7/1	light grey
10YR 8/1	light grey

content was 29 percent at the time of sampling. Carbonate contents range from 92 to 96 percent with a magnesium:calcium ratio of 1:35 to 1:92. Over 53 percent by weight of a pit sample (1 to 3 1/2 feet in depth) contains grains greater than 0.06 mm in diameter (Fig. 7) and 26 percent is retained on the No. 45 sieve (0.35 mm diameter particles). Of the 47 percent which passes the No. 230 sieve (0.06 mm) 12 percent is clay size and 88 percent silt size, as determined by standard hydrometer testing.

Microscopically the dry material is soft and flaky (Plate I, Fig. 1) and the coarser particles appear to be fragments of Tufa*. Shells are rare and Chara** are absent (Plate I, Fig. 2). Higher power magnification indicates a high degree of variation in sizes of dry particle agglomerations.

Assuming an average thickness of 2 feet over a radius of 100 feet the deposit is calculated to contain over 2300 cubic yards of marl. Dried samples were determined to have a specific gravity of 0.84 (a figure which appears to be abnormally low) and therefore a total reserve of over 1600 tons is contained within the deposit.

The principal mechanism for deposition is regarded to be precipitation of calcium carbonate from saturated groundwater emanating at or near surface. The direction of groundwater flow is probably from the northwest and other discharge points may be located at a similar elevation along the southeast-facing hillside which confines the north side of the Chain Lakes. Further investigation of marl is warranted in the area, particularly with a view towards locating larger deposits.

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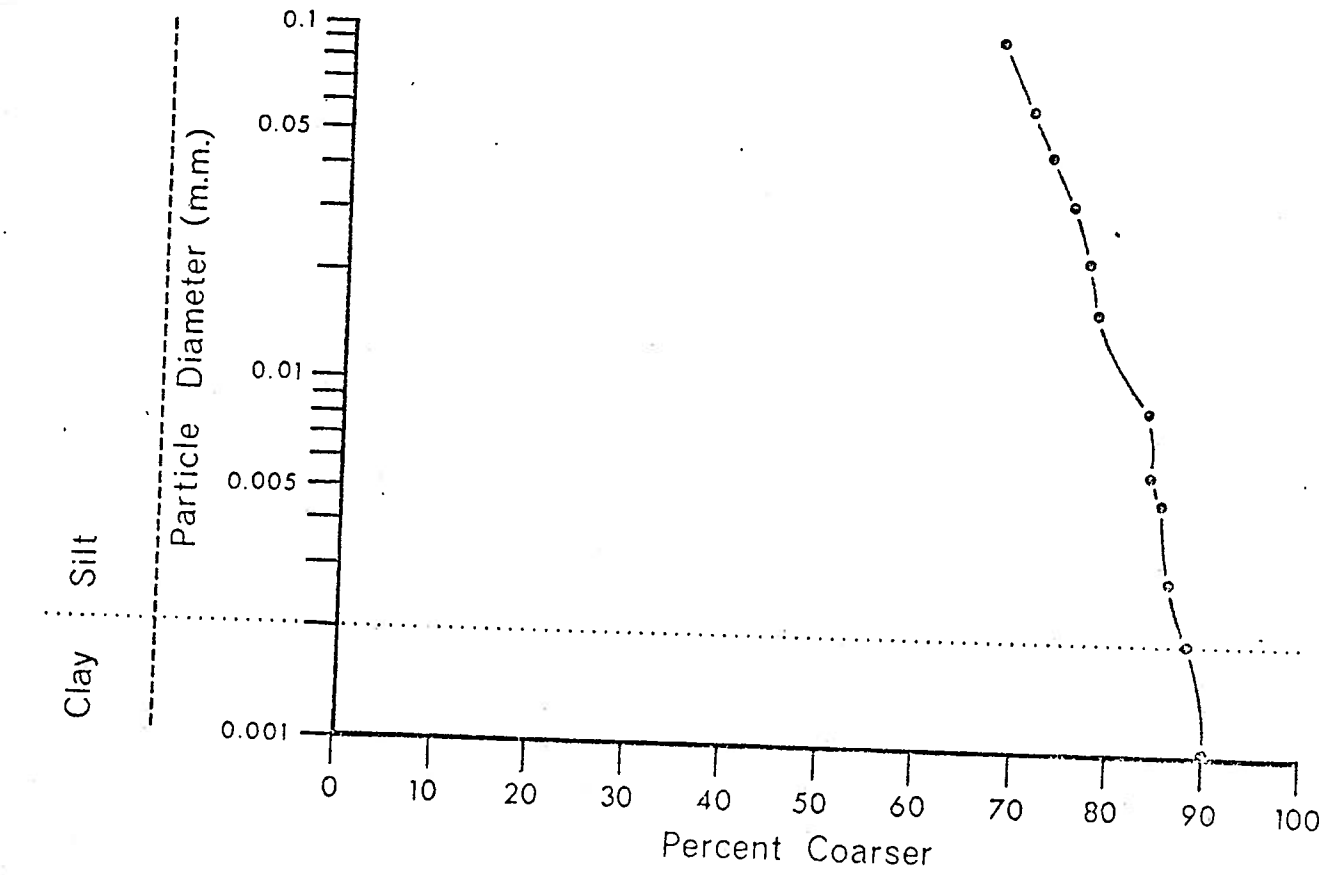
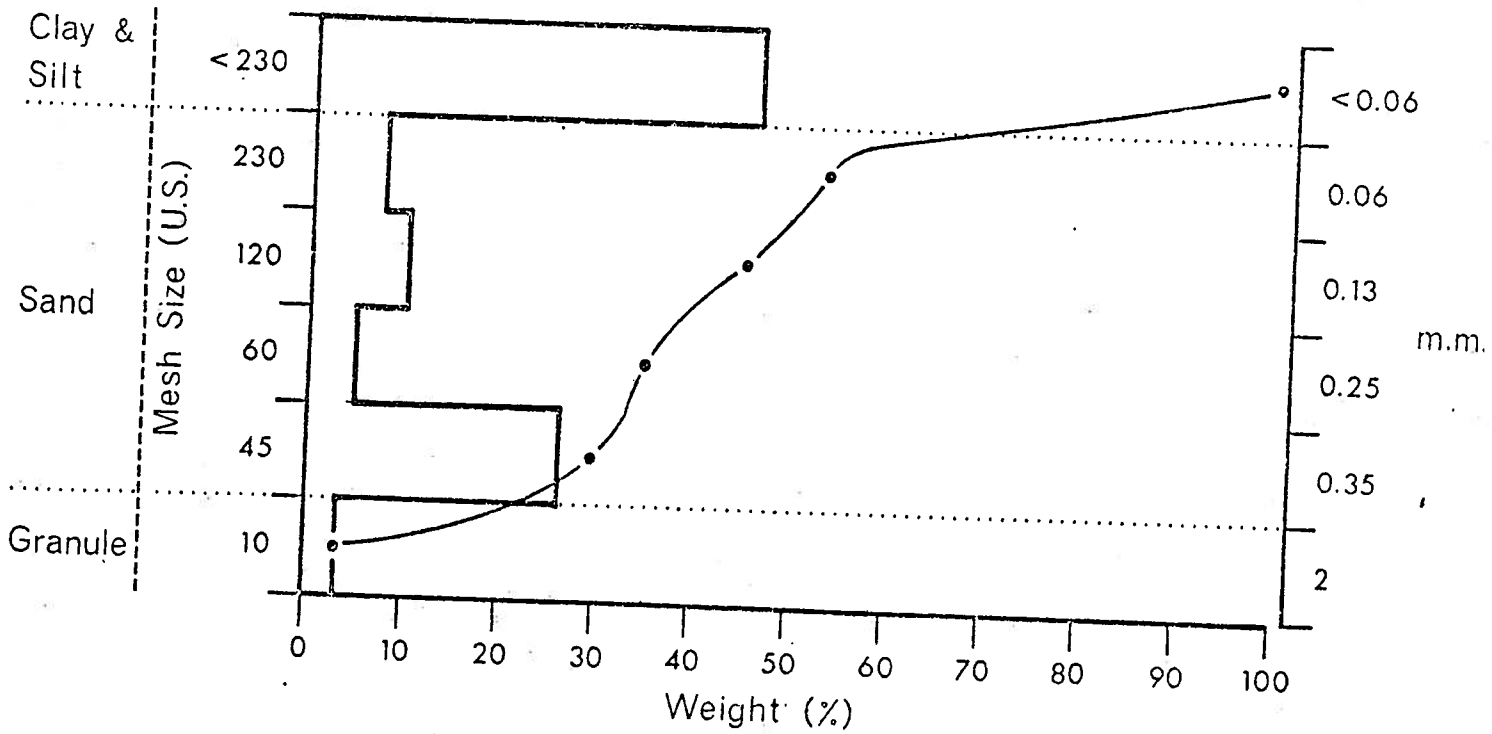
*Tufa is a term referring to a chemical sedimentary rock composed of calcium carbonate deposited from solution in the water of a spring or of a lake or from percolating groundwater.

**Chara is a plant, commonly listed among the Algae, which lives in shallow water and is rooted to the bottom. The plant contains in its tissues and bears on its surface an unusual amount of calcareous deposit such that large marl deposits have resulted from Chara alone.





Demmitt Pit

Figure 7. Particle Size Histogram and Cumulative Curves.

Bay Tree Deposit

The Bay Tree deposit, first discovered by Mr. Larry Loge of the local community, is located southeast of the village of Bay Tree. Access is by means of a number of gas well service roads in the manner indicated in figure 8. The site is 0.6 miles north of the nearest road in an open grassy bog at the confluence of two small streams. The marl is conspicuous as a grey residue below, and narrowly surrounding, a shallow pond approximately 250 feet in diameter (Fig. 9 and Plate II, Figs. 1 and 2). The pond is completely devoid of vegetation and the abundance of hoof prints indicates that it attracts big game as a watering site or salt lick. The 1:50,000 topographic map entitled "Bonanza 83M/13W" and air photos YC-359-5517-7 and YC-359-5517-8 include the site location (Lsd. 3 and 6, Sec. 15, Tp. 73, Rge. 12 W.5M).

Test hole 1 (Fig. 10) failed to fully penetrate the marl at a depth of 12 feet. Coloration varies from brownish grey to light grey to dull orange. All the samples retrieved were completely water saturated and no accurate determinations of moisture content were obtained. Carbonate contents generally decrease with depth from greater than 80 percent above 8 feet in depth to less than 45 percent below this level. Gastropod shells as well as ostracods and Chara are common throughout and a fetid odor is very prevalent.

Test hole 2 (Fig. 11), located 50 feet northwest of the pond edge, penetrated 5 feet of peat before encountering 7 feet of grey and black, highly organic marl with carbonate contents of less than 50 percent.

Magnesium:calcium ratios vary throughout the section from 1:22 to 1:34. A small amount of pond water was sampled which analysed 104 ppm calcium and 123 ppm magnesium.

The histogram and cumulative curves shown in figure 12 indicate less than 20 percent by weight of the surface sample from the hole 1 location is retained above the No. 230 sieve. Silt size grains constitute 82 percent of the sample passing the

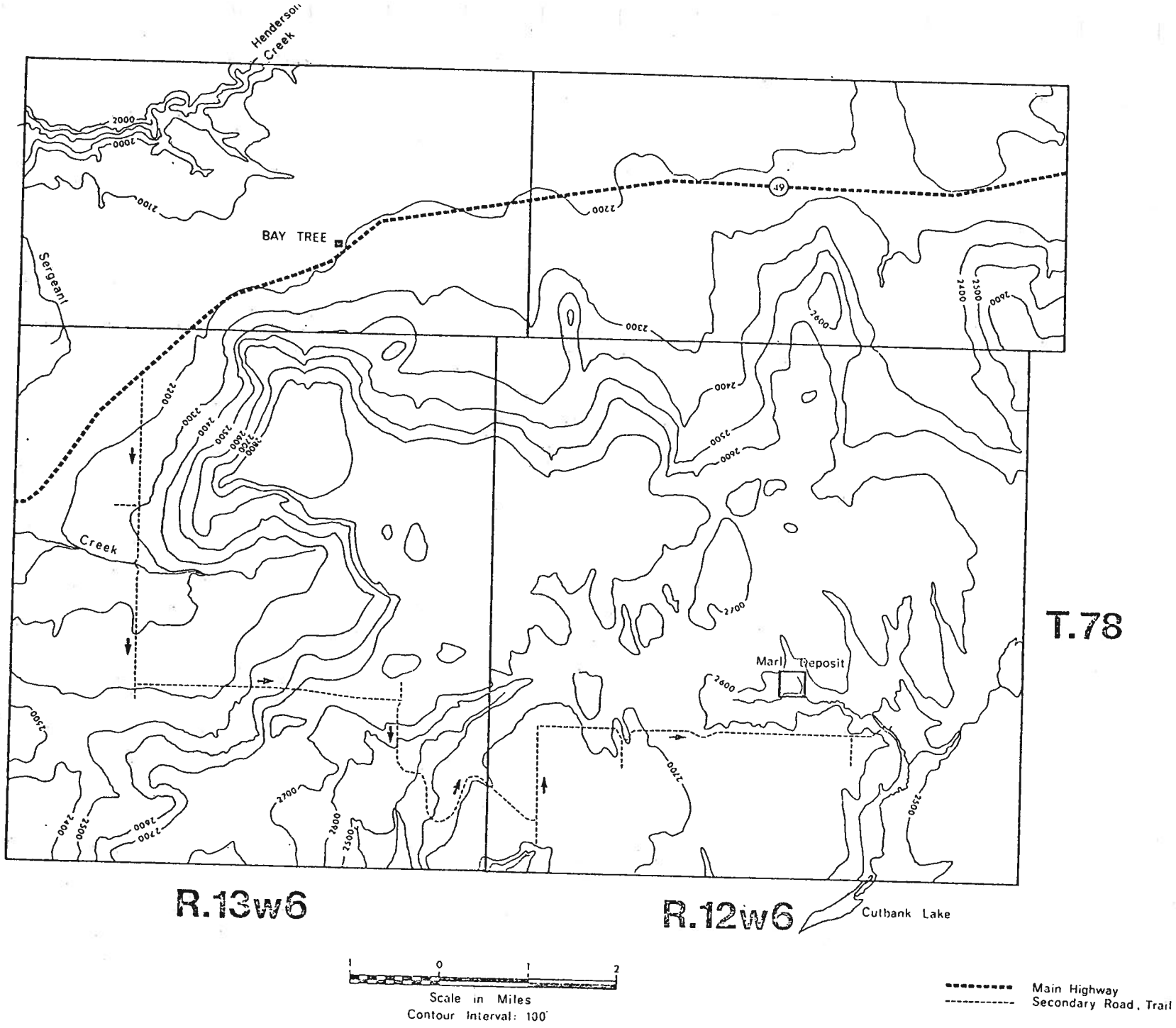


Figure 8. Location Map of the Bay Tree Area.

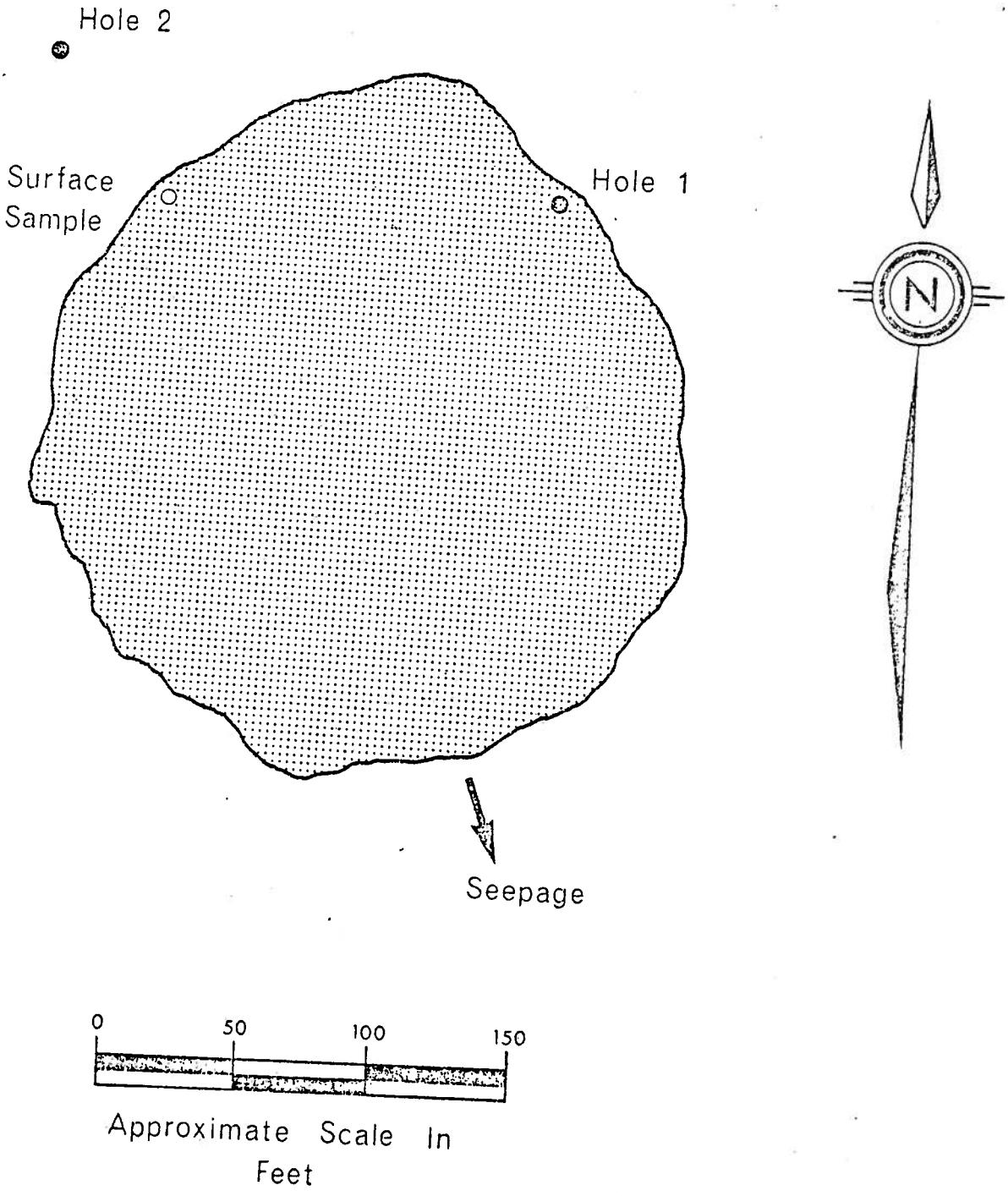
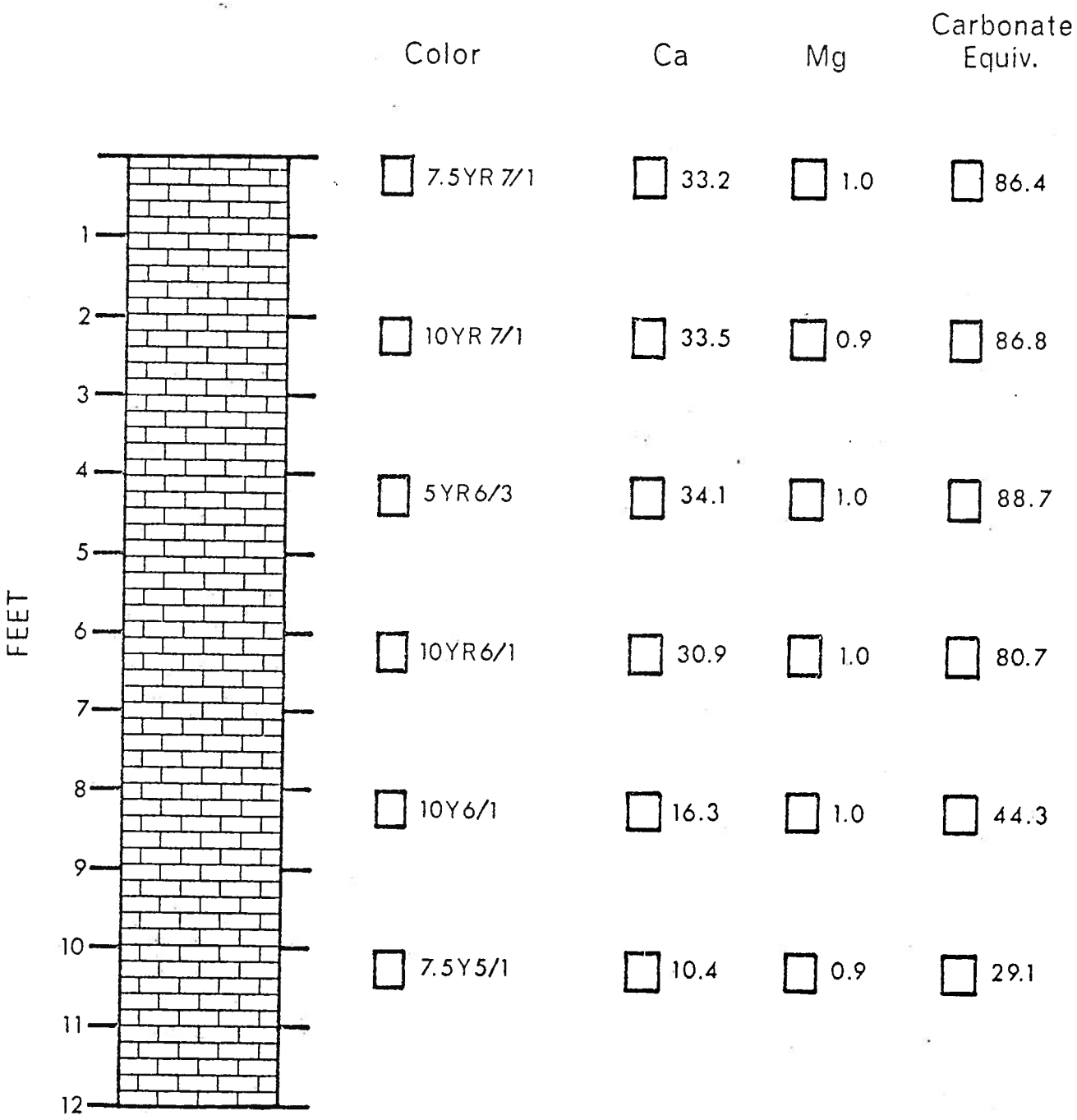
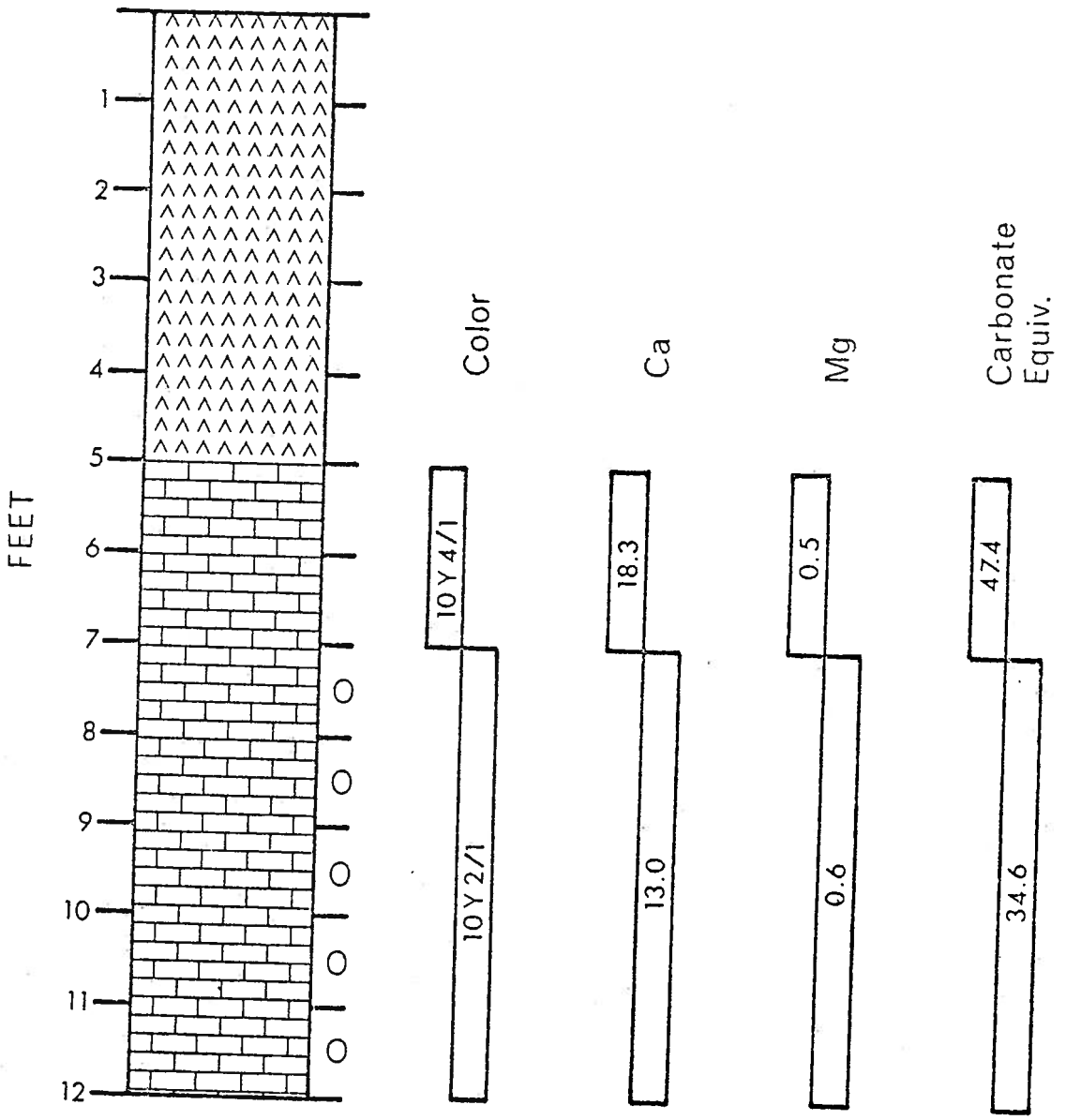


Figure 9. Detail of Bay Tree Deposit.



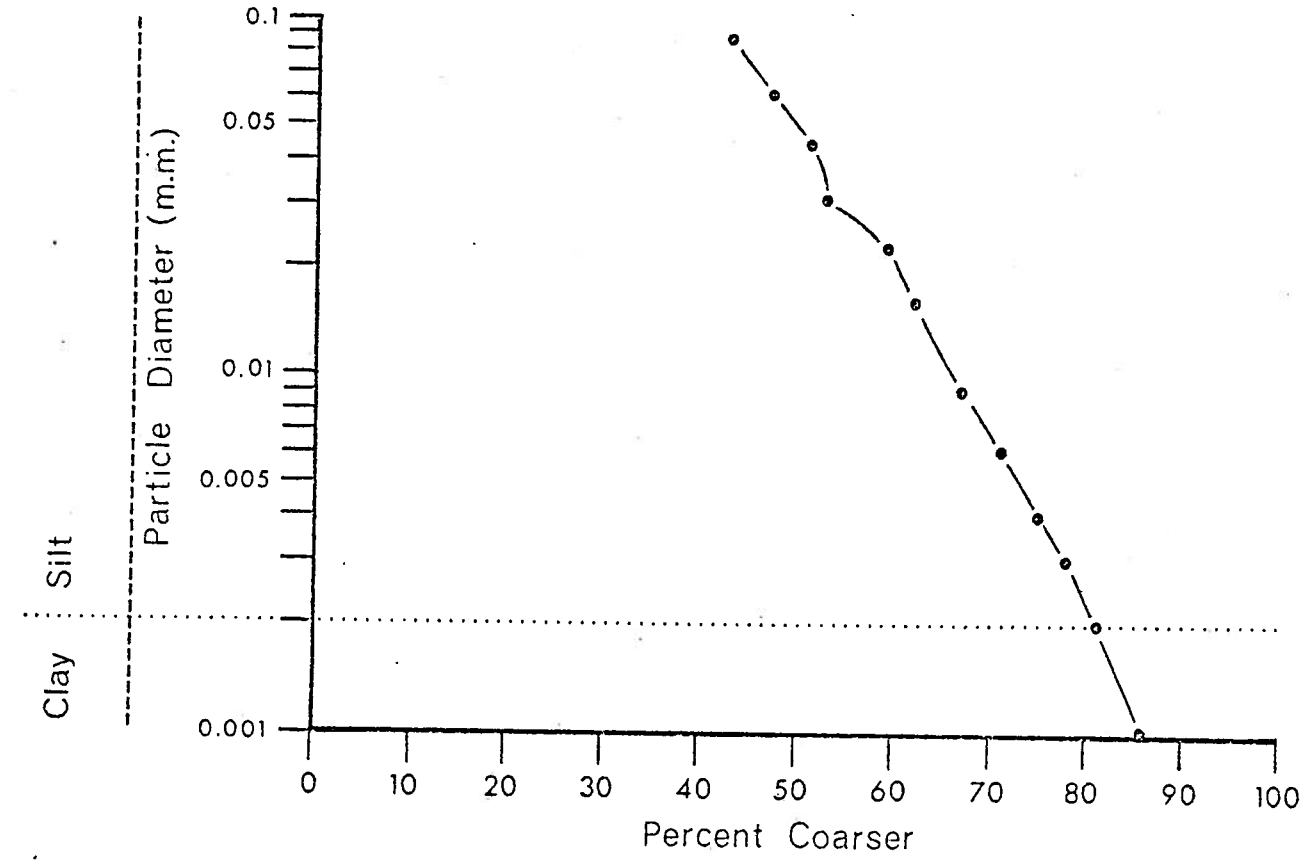
Bay Tree Deposit, Hole 1

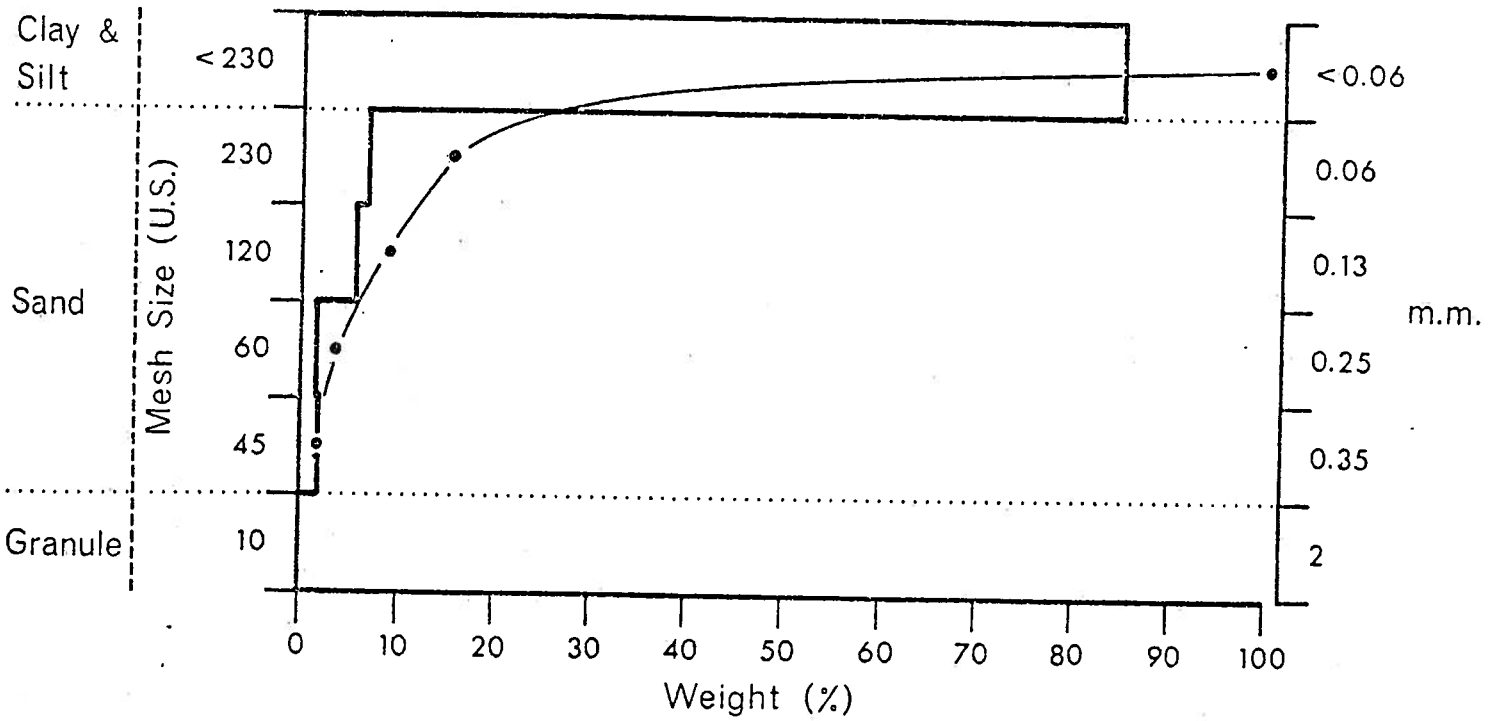
Figure 10.



Bay Tree Deposit, Hole 2

Figure 11.





Bay Tree Deposit

Figure 12. Particle Size Histogram and Cumulative Curves.

No. 230 sieve and the remaining 18 percent of the fines fall within the size range of clay particles. High power magnification shows irregular grain sizes and configurations (Plate II, Fig. 3).

A reserve estimate, based on a surface area 250 feet in diameter and a minimum depth of 8 feet, amounts to a volume of 14,500 cubic yards. The dry specific gravity of the marl varies from 0.8 to 1.0. Assuming an average specific gravity of 0.9 the deposit is calculated to contain 11,000 tons of marl. It should be noted that the pond may be easily drained by means of a minimum amount of ditching on the south side. The greatest development problem would probably be the construction of an access trail from the adjacent service road.

The marl is interpreted to originate from carbonate-rich groundwaters discharging along the south side of the adjacent upland area. The relative abundance of gastropods, ostracods and Chara suggest organic influences. However, the latter effect is thought to have resulted from pond conditions favorable to the hosting of such aquatic organisms.

There are distinct possibilities for further deposits in the area. In fact, very thin layers of marl, at or near surface, were noted a few hundred yards to the west of the pond, along the bank of the main stream. Groundwater discharge conditions may be in effect elsewhere in the immediate vicinity with less obvious surface expression.

Spirit River Deposit

A cultivated field 2 miles southwest of Spirit River is the site of a noteworthy tufaceous marl deposit. Figure 13 shows the location of the occurrence which is situated in the southwest quarter of Sec. 16, Tp. 78, Rge. 6, W.6M. The "Rycroft 83M/15W" topographic sheet and air photos YC-359-5517-29 and YC-359-5517-30 provide detailed coverage. The field slopes very gently towards a tributary of the Spirit River to the southeast. The topsoil is noticeably light in color and scattered

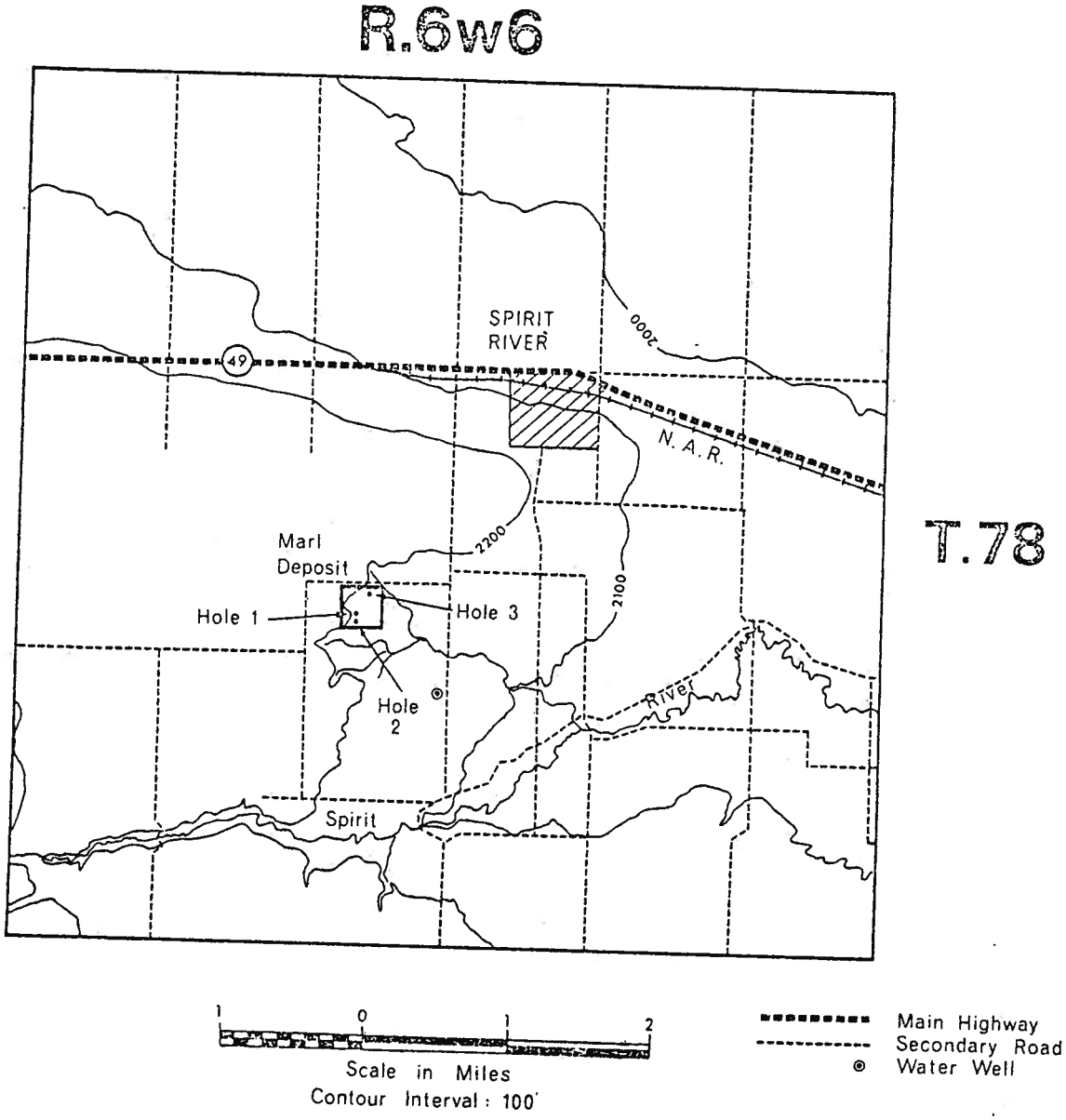


Figure 13. Location Map of the Spirit River Deposit.

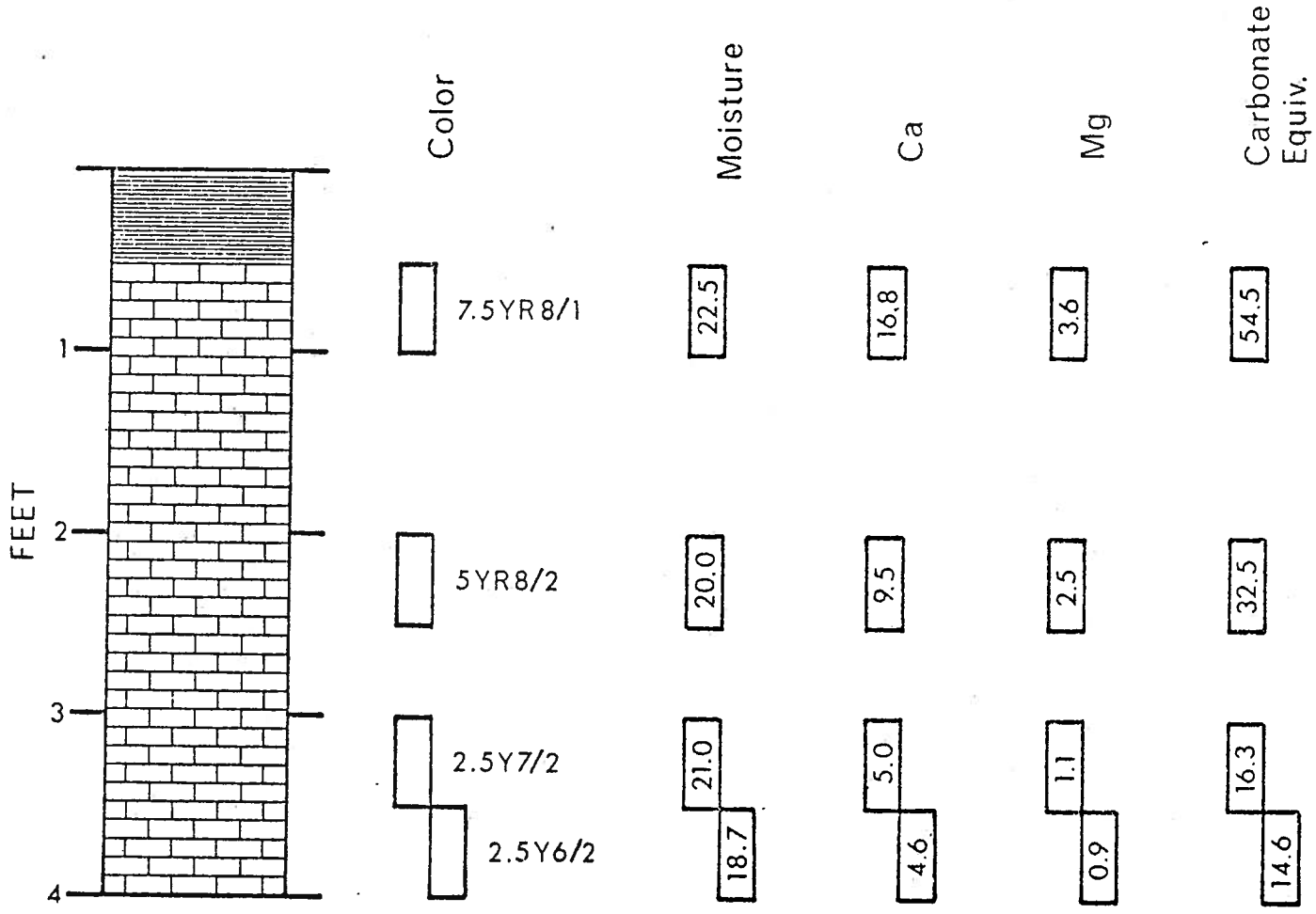
fragments of tufa, up to 6 inches or more in diameter, are common. Blocks of brown siltstone scattered along the elevated northwestern edge of the field suggest the proximity of Upper Cretaceous bedrock to surface.

Three test holes were drilled and holes 1 and 2 were located within a few tens of feet of one another. A thickness of 3 1/2 to 4 feet of marl was tested (Figs. 14 and 15). An organic overburden 6 to 8 inches thick overlies the carbonate and a relatively barren clay is encountered below the deposit. Hole 3, in the northeast corner of the field yielded 2 1/2 feet of low-grade marl below 1 1/2 feet of clay and topsoil (Fig. 16). The dry marl from all the test holes varies in color from light grey to light yellow. Moisture contents ranged from 18 to 24 percent at the time of testing. Carbonate percentages decrease with depth in each hole. In hole 1 values range from 55 percent at 6 inches to 15 percent at 3 1/2 feet. Similarly, in hole 2, the carbonate content drops from 63 percent at 6 inches to 30 percent at 4 feet. Percentages of carbonate at the location of hole 3 do not exceed 21 percent.

The ratio of magnesium to calcium is relatively high, ranging from 1:4 to 1:11. The analyses on a nearby water well are given in table II and the dissolved solids do not appear to be abnormally high.

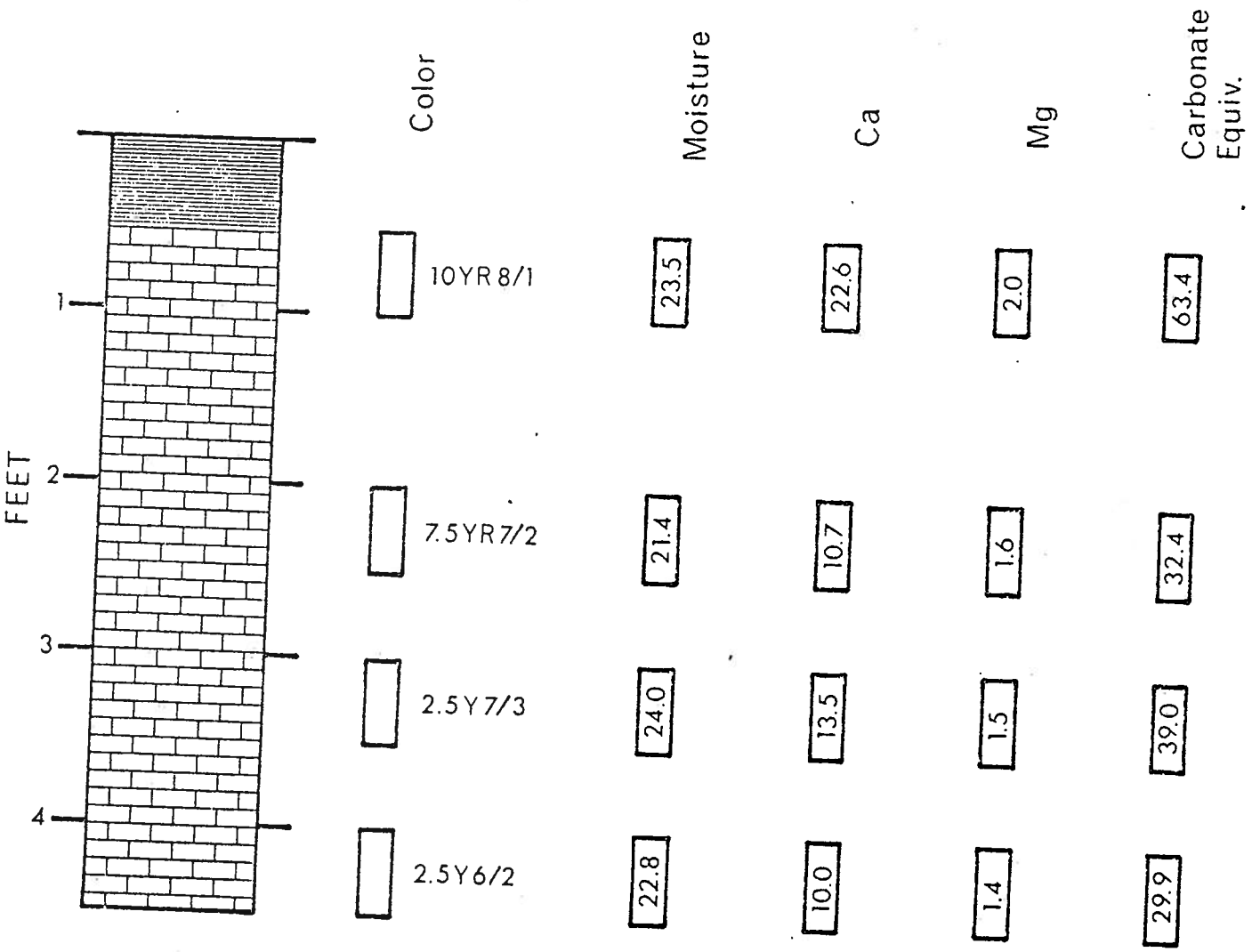
Approximately 21 percent by weight of the sample taken between 6 inches and 1 foot in hole 2 is retained above the No. 230 sieve (Fig. 17). These particles are predominately tufa fragments, with occasional gastropods, ostracods and tubular structures (Plate III, Fig. 1). Clear quartz grains and dark mineral grains or rock fragments are also common accessory materials (Plate III, Fig. 2). The remaining 79 percent of the sample is mainly comprised of particles in the silt size range (76 percent) and 24 percent of the minus No. 230 sieve fraction are clay sizes (Plate III, Fig. 3).

Total reserves of the deposit are difficult to estimate with the limited amount of information available. Further testing would be required to delineate the extent of



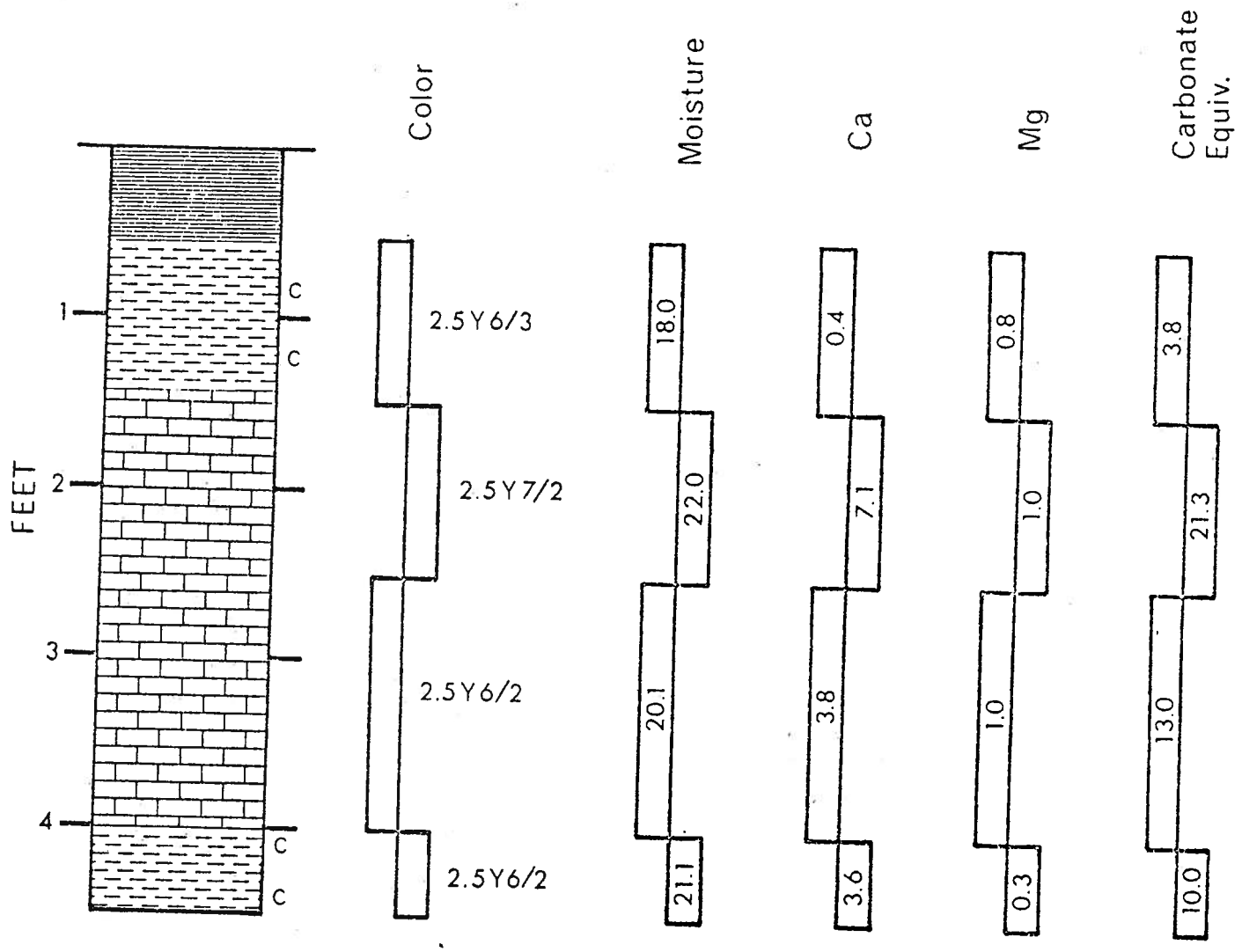
Spirit River Deposit, Hole 1

Figure 14.



Spirit River Deposit, Hole 2

Figure 15.



Spirit River Deposit, Hole 3

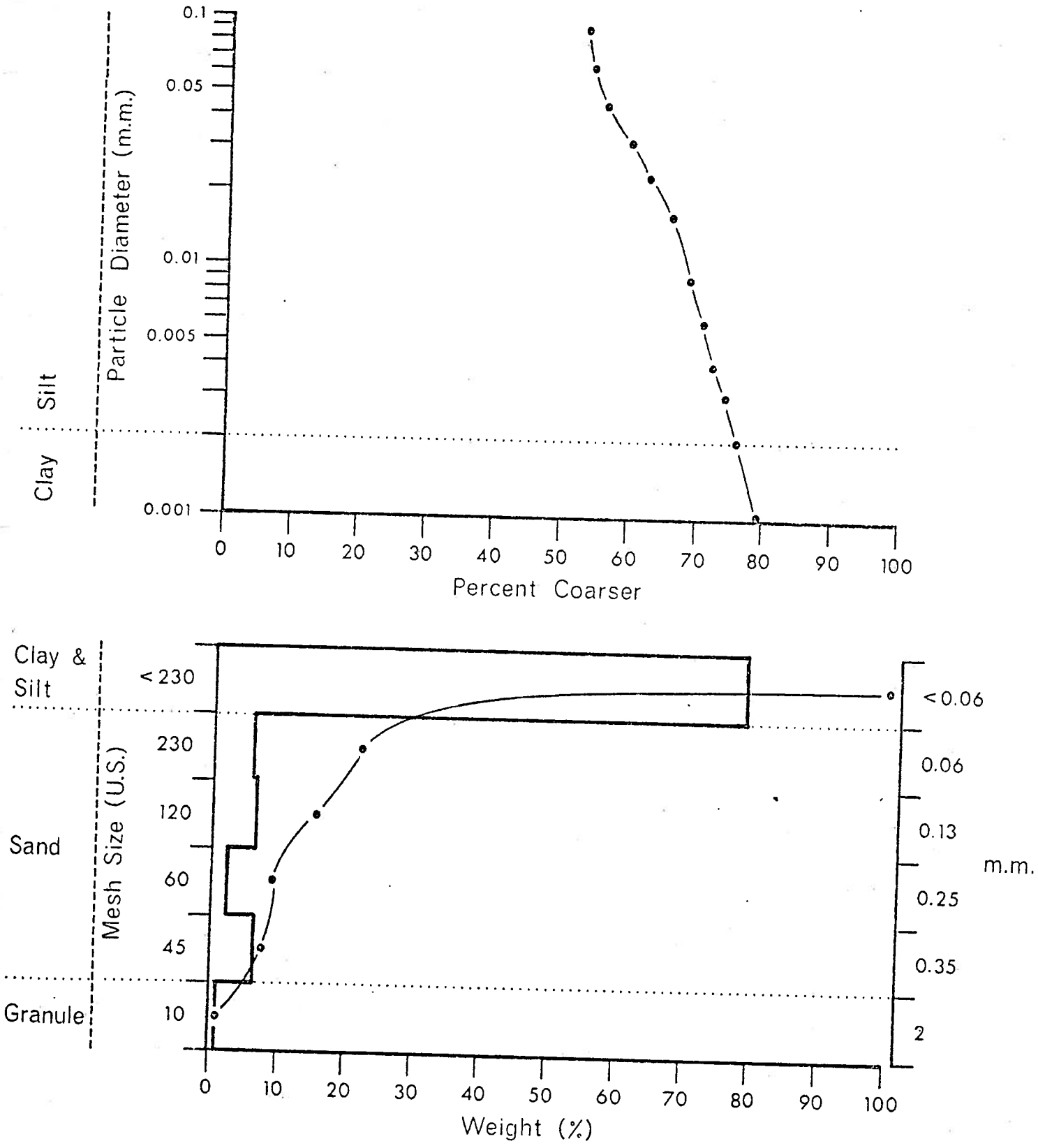
Figure 16.

Table II. Analysis of water from a well located in NE 9-78-6 W6M

Well depth (ft): 16

Depth to water (ft): 8

Total solids (ppm)	754
Hardness (ppm)	550
Sulfates (SO_4) (ppm)	174
Alkalinity (ppm)	450
Iron (ppm)	3
Ca and Mg (%)	86
Na and K (%)	14
Chlorides (%)	1
CO_3 and HCO_3 (%)	71
SO_4 (%)	28



Spirit River Deposit

Figure 17. Particle Size Histogram and Cumulative Curves.

the high-grade material in the area of holes 1 and 2. It appears likely that there is at least as much marl available at the Spirit River site as would be recoverable from the Demmitt deposit.

Groundwater discharge from shallow buried outcrop is considered responsible for deposition of the carbonate.

A marl deposit located in Lsd. 12, Sec. 21, Tp. 78, Rge. 7, W.6M (8 miles west of Spirit River) was recently disclosed to the writer (Doug Hackbarth, personal communications). The occurrence is described as a shallow, spring-fed pond apparently very similar to the one located near Bay Tree. A water analysis is provided in table III which shows an abnormally high magnesium content, a characteristic shared by the Spirit River marl.

Grimshaw Deposit

An excellent reserve of high-grade marl is located in Lsd. 12, Sec. 14, Tp. 82, Rge. 24, W.5M, approximately 7 miles south-southwest of Grimshaw (Fig. 18). Details of locality and terrain are available from the topographic map "Grimshaw 84C/4E" and air photos 162A-5605-2346-52-68 and 162A-5605-2346-52-69. Figure 19 illustrates the detail of the immediate vicinity of the deposit. A 10-foot high mound centred in a field in the west half of Lsd. 12 dominates the 1/2 mile-wide feature (Plate IV, Fig. 1). The topsoil at the site is light in color and chunks of porous tufa, up to 1 foot across, are scattered throughout the deposit, especially near the top of the mound (Plate IV, Fig. 2).

Four test holes were drilled in the material: one at the highest point on the mound and three others along an approximate northwest-southeast line, towards the southeast fringe of the deposit (Figs. 20, 21, 22 and 23). The marl was found to exceed 12 feet in thickness at the first hole and thins to 3 feet thick in the fourth hole 550 feet away. Approximately 8 inches of calcareous topsoil is the only overburden present. Coloration varies from light grey to light yellow with varying

Table III. Analysis of water from a spring located in Lsd. 12-21-78-7 W6M

Total solids (ppm)	7802
Hardness (ppm)	5324
Ca (ppm)	342
Mg (ppm)	1090
Sulfates (SO_4) (ppm)	4235
Chlorides (ppm)	24
Alkalinity (ppm)	1712
Nitrate (NO_3) (ppm)	0.3
Fluoride (ppm)	0.08
Mg (%)	68.4
Ca and Mg (%)	81.4
Na and K (%)	18.6
Chlorides (%)	0.5
CO_3 and HCO_3 (%)	28.0
SO_4 (%)	71.6
Na (%)	556.0
K (%)	5.4
CO_3 (%)	0.0
HCO_3 (%)	2089.3
pH (%)	7.2

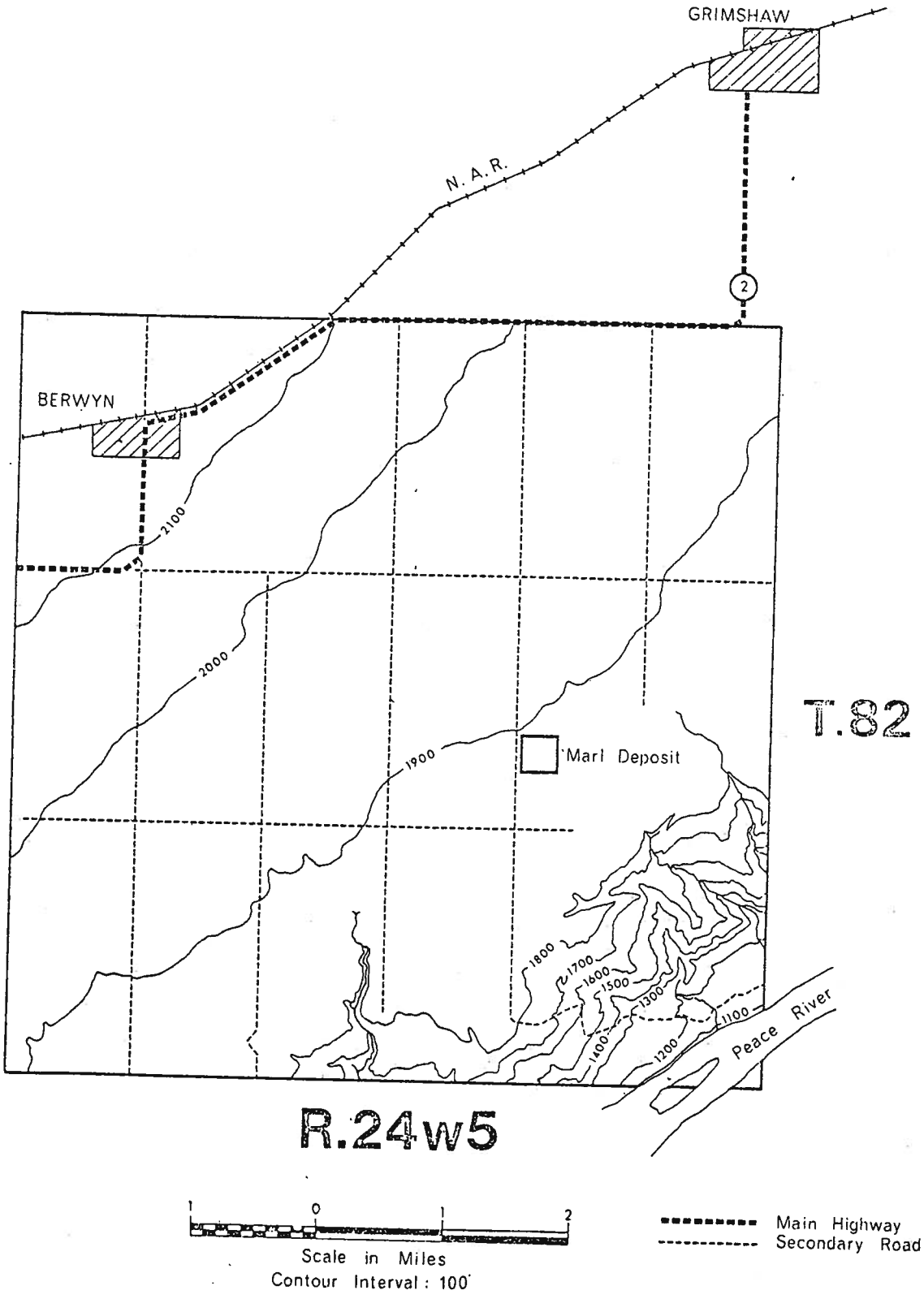


Figure 18. Location Map of the Grimshaw Deposit.

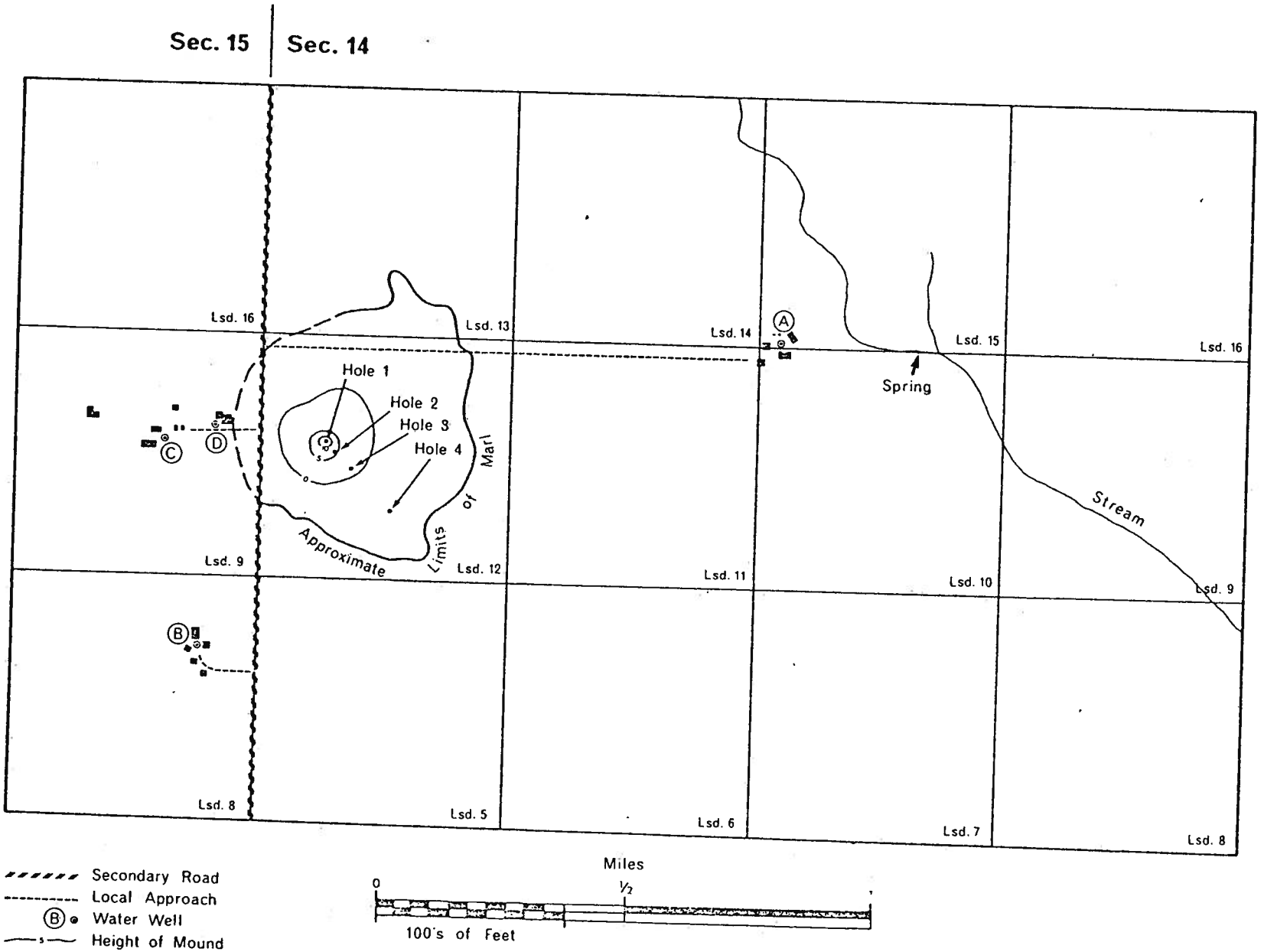
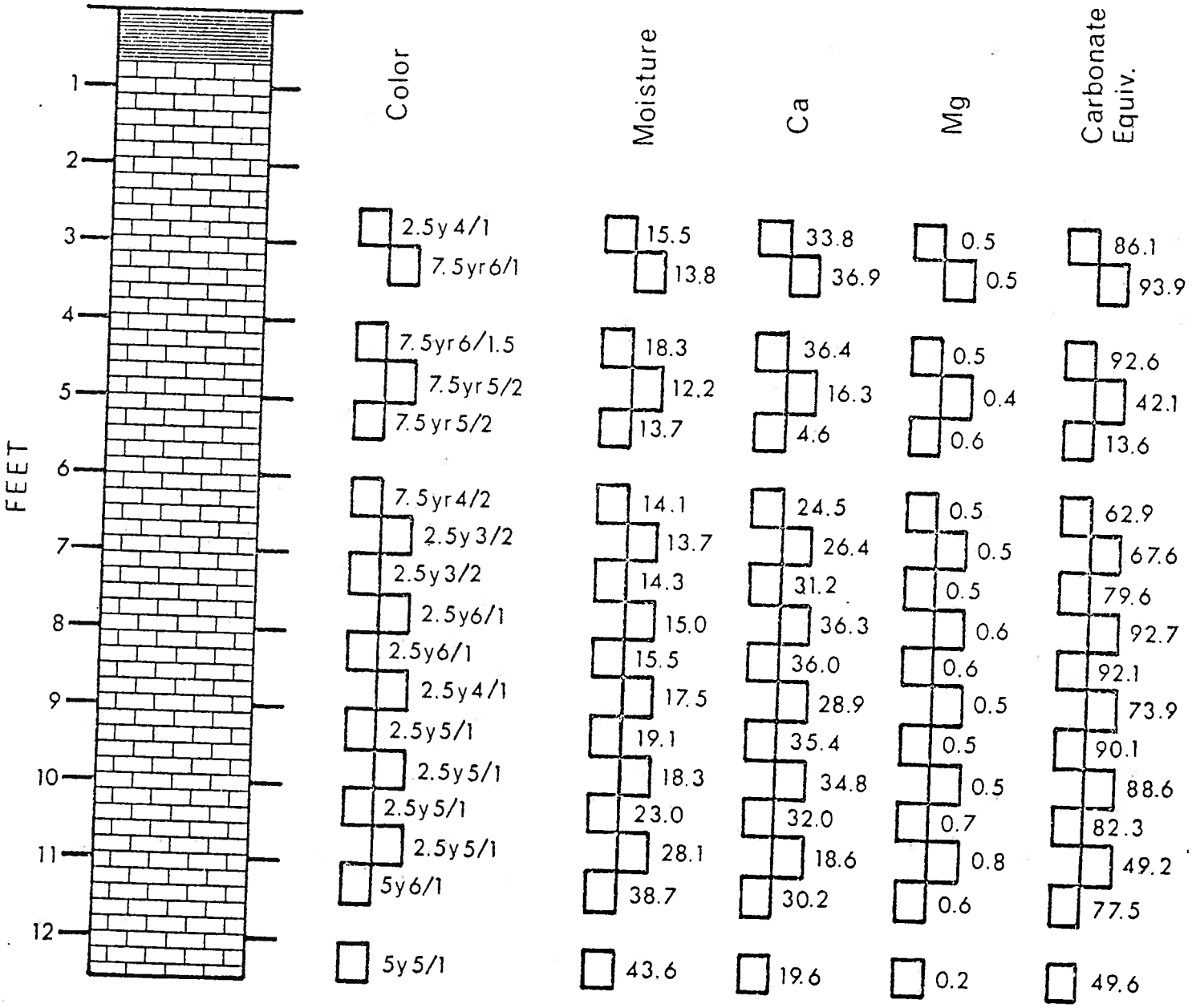
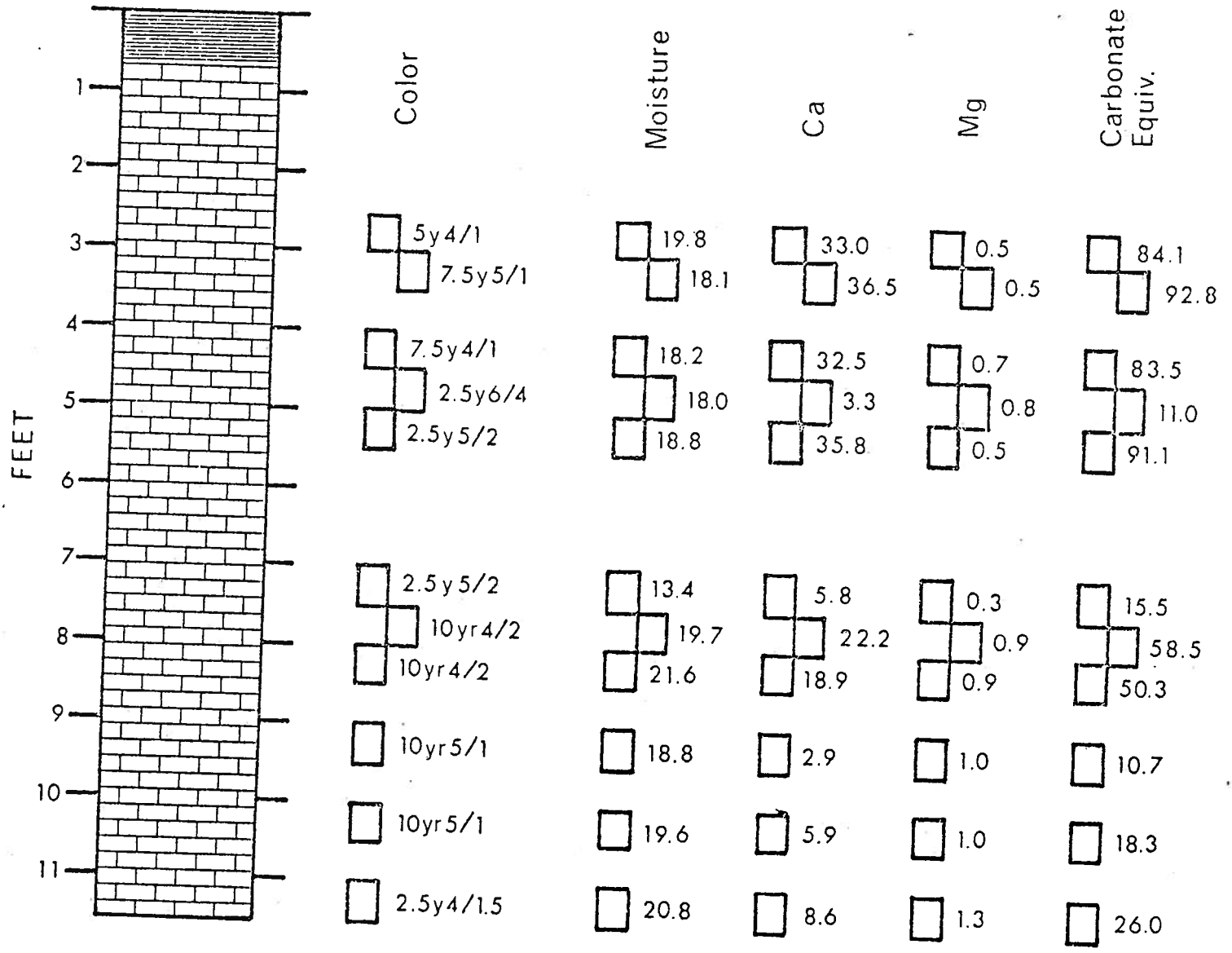


Figure 19. Detailed Location Map of the Grimshaw Deposit.



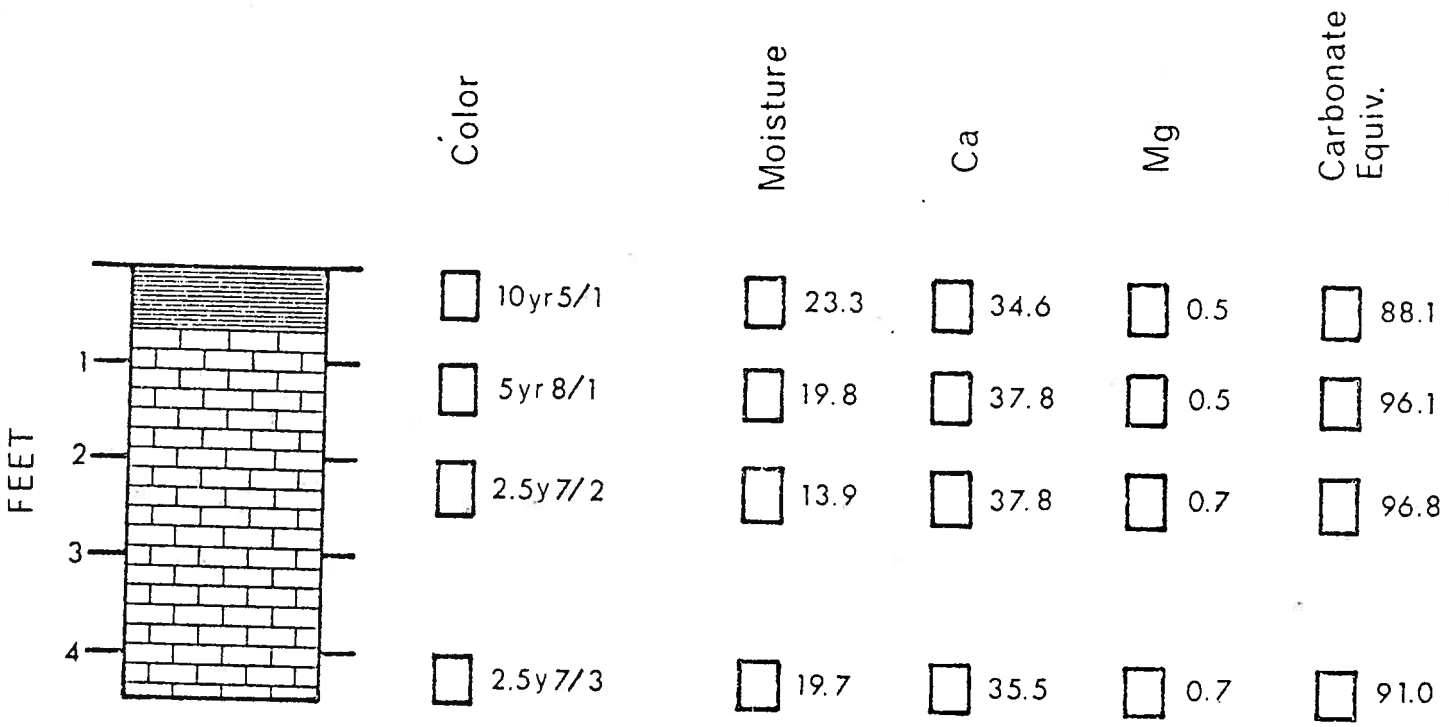
Grimshaw Deposit, Hole 1

Figure 20.



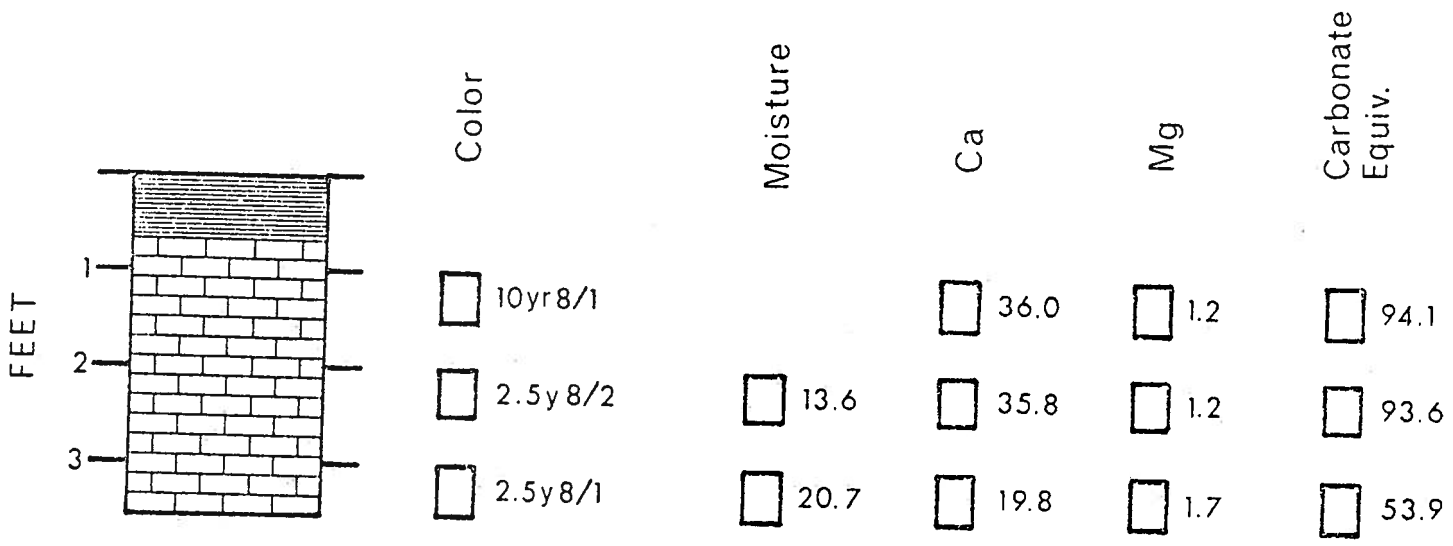
Grimshaw Deposit, Hole 2

Figure 21.



Grimshaw Deposit, Hole 3

Figure 22.



Grimshaw Deposit, Hole 4

Figure 23.

amounts of brownish tones. A thin red brown layer occurs below the marl in holes 2, 3 and 4 and below this is barren clay.

The average moisture content, at the time of testing, was slightly less than 20 percent. Values as low as 12 percent were occasionally encountered in the section. In each test well the moisture contents increase slightly with depth and in hole 1 very damp samples were retrieved from below 11 feet in depth, indicating a level at or near the water table. Formerly, a water well was located at the top of the mound which yielded potable water in good quantity at 10 feet (Tokarsky, 1967).

Chemical analyses show remarkably high amounts of carbonate with values commonly exceeding 85 percent. Thin beds grading as low as 11 percent carbonate are present. Magnesium:calcium ratios vary between 1:4 to 1:98. However, magnesium contents are only high on the low-grade materials and the ratio typically averages between 1:40 and 1:75 on marls with high carbonate percentages.

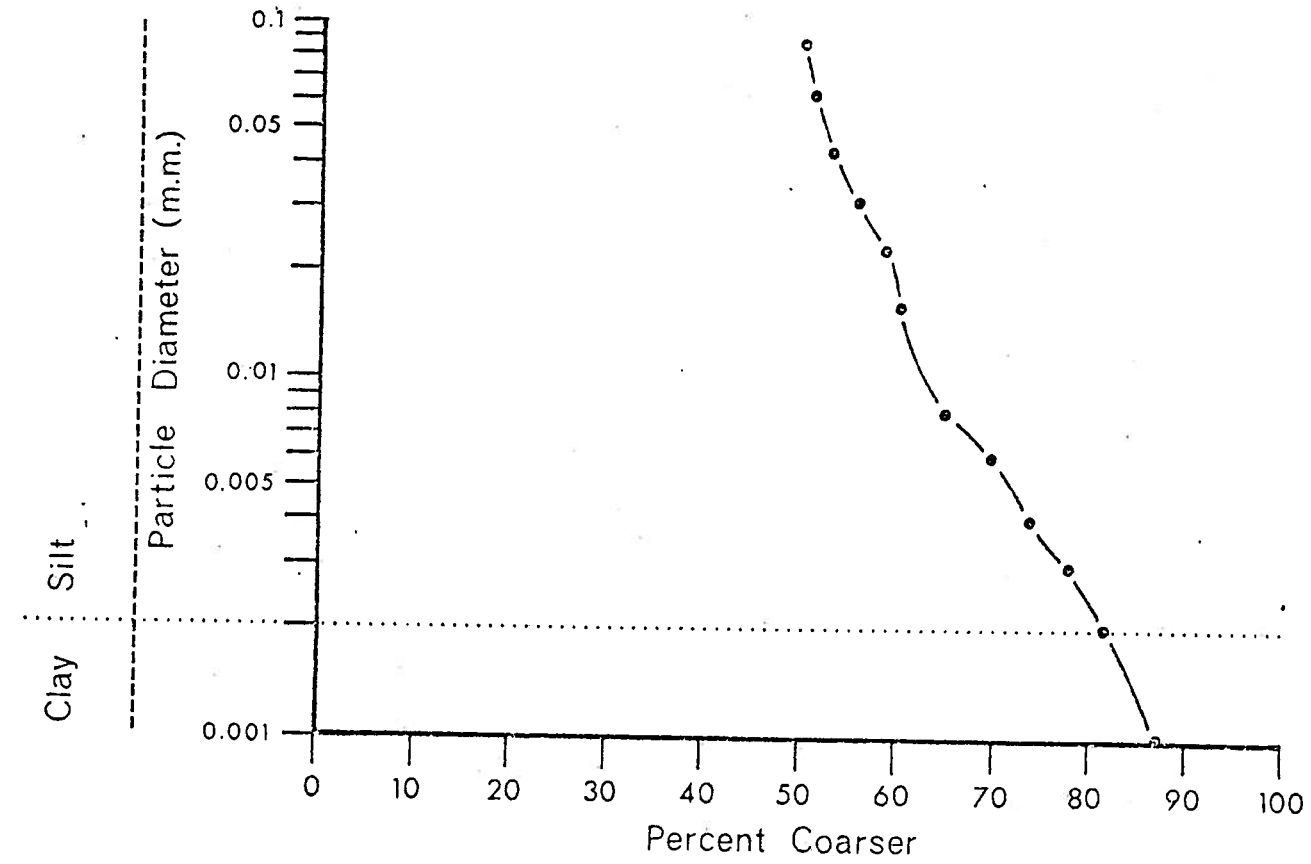
Analyses of water from several surrounding wells and one nearby spring are given in table IV. In each case there is little evidence of unusually high amounts of dissolved solids in shallow groundwaters of the immediately surrounding areas.

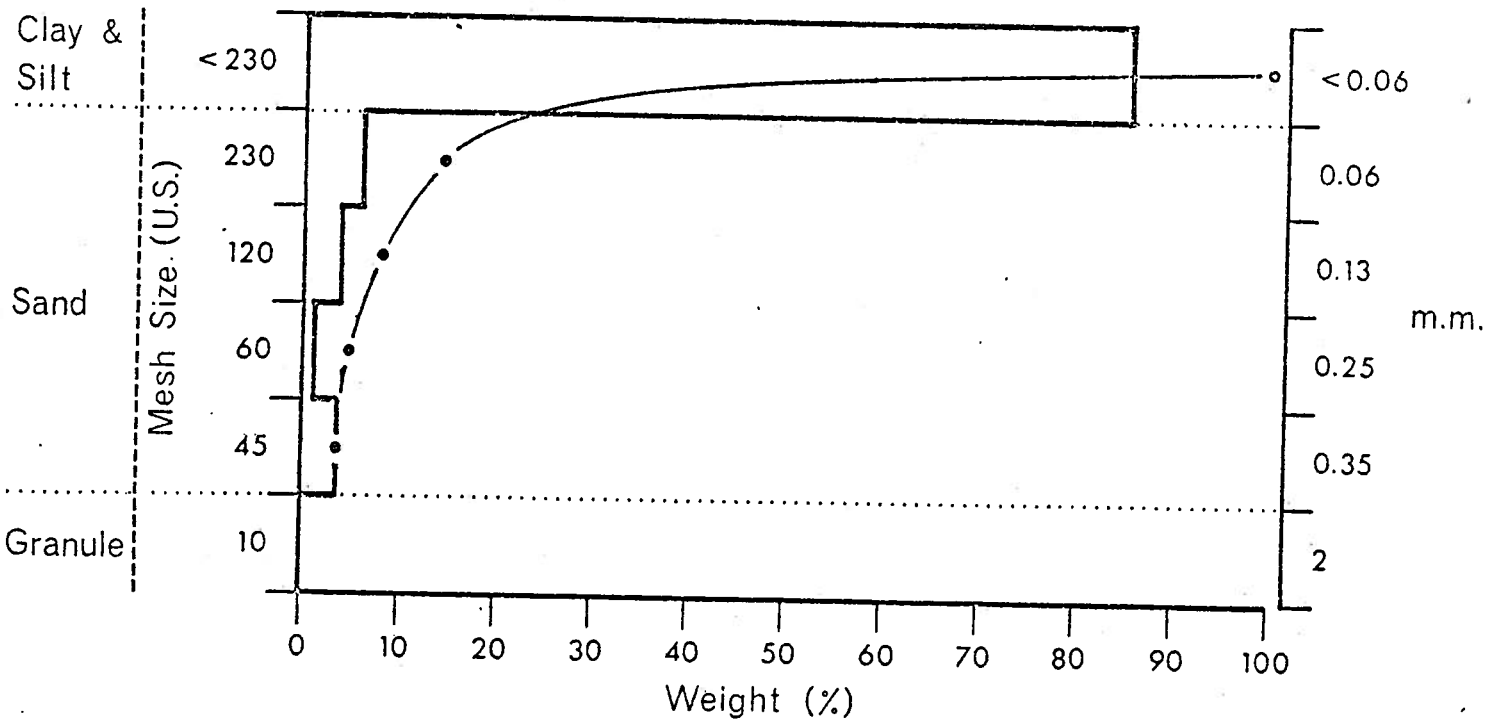
Coarse particles (greater than 0.06 mm in diameter) constitute approximately 15 percent by weight of a bulk sample taken from hole 4 (Fig. 24). Gastropods, ostracods and nondescript marl grains are the main constituents (Plate V, Figs. 1 and 2). The remaining 85 percent is mainly silt (82 percent of the fines) and some clay sizes (18 percent). Figure 3 of plate V illustrates the nature of the material under high magnification.

Reserves of marl are calculated on the basis of an arbitrary average thickness of 4 feet over a radius of 600 feet. As a result, the deposit contains approximately 160,000 cubic yards and, assuming a specific gravity of 1.0, the total dry, pulverized product available is 135,000 tons.

Table IV. Analyses of water from wells and springs surrounding the Grimshaw marl deposit

Well	A	B	C	D	
Depth (ft)	63	60	26	62	Spring
Total solids (ppm)	432	364	674	446	318
Hardness (ppm)	250	200	415	310	245
Ca (ppm)	64.9	42.8	110.1	68	68.9
Mg (ppm)	21.4	22.6	34	34	17.8
Sulfates (SO_4) (ppm)	173	165.6	160.8	141	131
Chlorides (ppm)	0	0	28	3	0
Alkalinity (ppm)	150	120	280	250	140
Nitrate (NO_3) (ppm)	0	0	85.95	0	8
Iron (ppm)	0	61	0.2	7	0.2
Mg (%)	27	32	25	35	26
Ca (%)	49	36	50	42	61
Ca and Mg (%)	76	68	75	77	87
Na and K (%)	24	32	25	23	13
Chlorides (%)	0	-	7	1	0
CO_3 and HCO_3 (%)	45	41	50	60	50
SO_4 (%)	55	59	30	39	48
NO_3 (%)	-	-	12	-	-





Grimshaw Deposit

Figure 24. Particle Size Histogram and Cumulative Curves.

The origin of the associated moundal feature is speculative. The abundance of shelled organisms suggests ponded conditions although the absence of Chara and other fossil plant materials would be indicative of an environment unsuitable for vegetative growth. Tokarsky interprets the land form as a fossil pingo (a mound raised by frost action above the permafrost) in a remnant pond after drainage of glacial Lake Fahler. Normal groundwater phenomena are precluded as primary genetic determinants by this writer because of the noncharacteristic morphology as a local discharge site, the apparent lack of spring water influences, and the absence of calcium-magnesium saturation of closely neighbouring well waters. However, the water table is relatively close to surface beneath the mound and the presence of tufa fragments would suggest at least localized recirculation of calcium carbonate enriched groundwaters.

Summary

The four marl deposits studied in the Peace River area of northwestern Alberta yield material favorable for commercial agricultural liming requirements. Reserves near Demmitt are small (approximately 1600 tons) although the quality is excellent (greater than 90 percent carbonate). The site is well drained and easily worked but access is poor.

The Bay Tree deposit contains moderate reserves (approximately 11,000 tons) and the marl quality is good (normally greater than 85 percent carbonate). The site would require drainage before development but this is not considered to be a major problem. However, the prospect must be reached by travelling 12 miles of poorly maintained road and a 1/2 mile access road would have to be constructed as an approach route onto the property.

The grade of the marl at Spirit River is relatively low (15 to 63 percent carbonate) and no determinations of reserves are possible at this time. The tonnages available are at least as great as those at Demmitt and may be considerably greater. Access is excellent and no site development problems would be anticipated.

The Grimshaw deposit is probably most favorable for future development in terms of quality and quantity. The marl is of good to excellent grade (mainly greater than 80 percent carbonate). Approximately 135,000 tons of product can be recovered without moisture or site access problems.

Marl from the Demmitt locality is relatively coarse-textured with over 50 percent by weight within the sand and granule size ranges. Bay Tree and Spirit River carbonates have approximately 20 percent by weight of the particles within a similar size range. Approximately 15 percent of the material at the Grimshaw deposit belong to the sand size fractions. Ratios of clay to silt sizes are as follows: Demmitt — 1:7; Bay Tree — 1:5; Spirit River — 1:3; and Grimshaw — 1:5. Thus the minus No. 230 sieve fractions at the Spirit River site are high in clay sizes and those at the Demmitt deposit are high in silt.

Figure 25 is included to summarize some of the compositional aspects of the marl. The X-ray diffraction patterns for the Demmitt, Bay Tree and Grimshaw deposits are remarkably similar due to the high calcite contents. The Bay Tree and Grimshaw marls contain trace amounts of an additional, poorly-documented mineral tentatively identified as a calcium fluoride chloride. Measureable amounts of quartz were detected in the Bay Tree material. The Spirit River deposit differs compositionally from the others in that it contains relatively high amounts of dolomite and quartz. In addition, a mineral interpreted to be a calcium silicate also occurs in trace quantities.

References

Tokarsky, O., 1967: Geology and Groundwater Resources of the Grimshaw-Cardinal Lake Area, Alberta; unpublished M. Sc. thesis, University of Alberta.

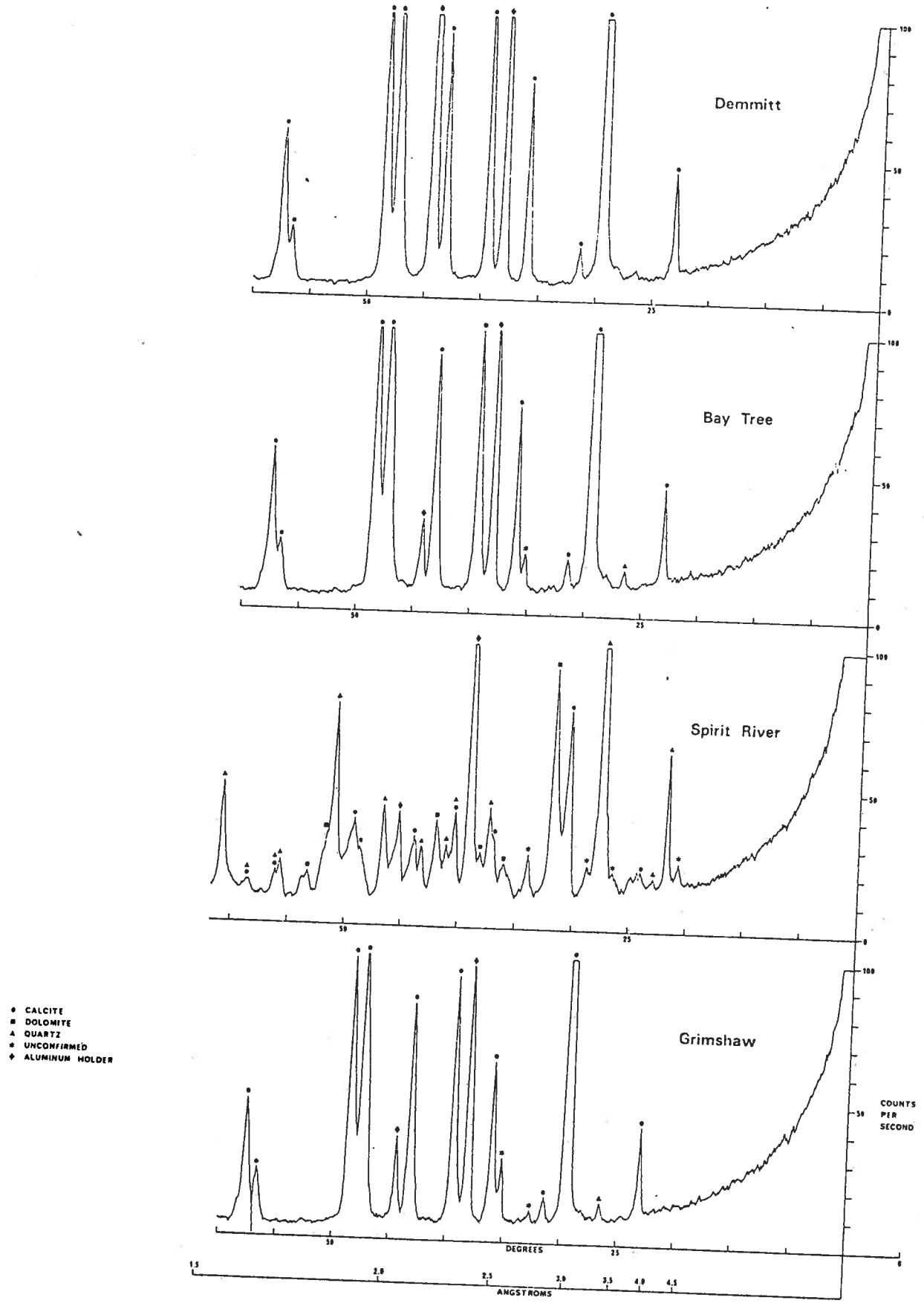


Figure 25. X-ray Diffraction Patterns.

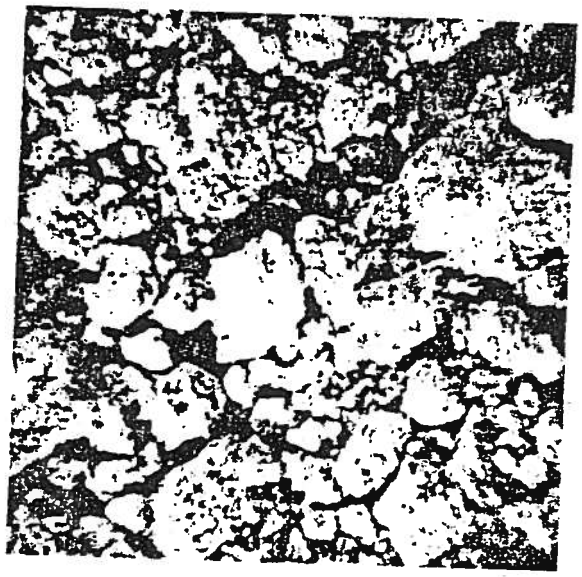
PLATE I

Demmitt Deposit

Figure 1. Pit sample, 10X

Figure 2. Tufa fragments retained on the No. 45 mesh sieve, 10X

Figure 3. Pit sample, 125X



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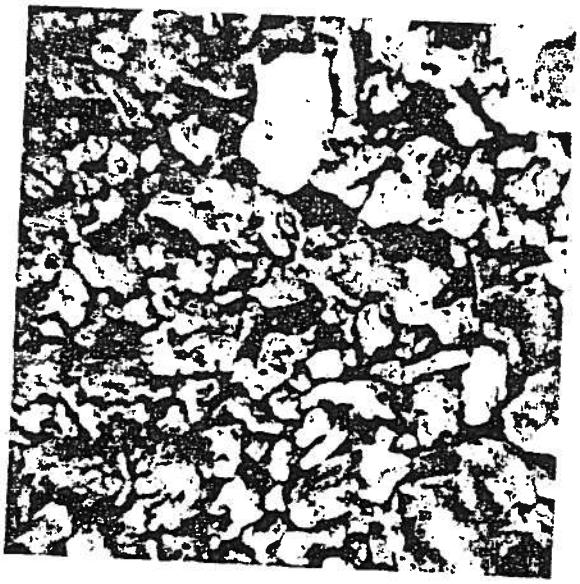

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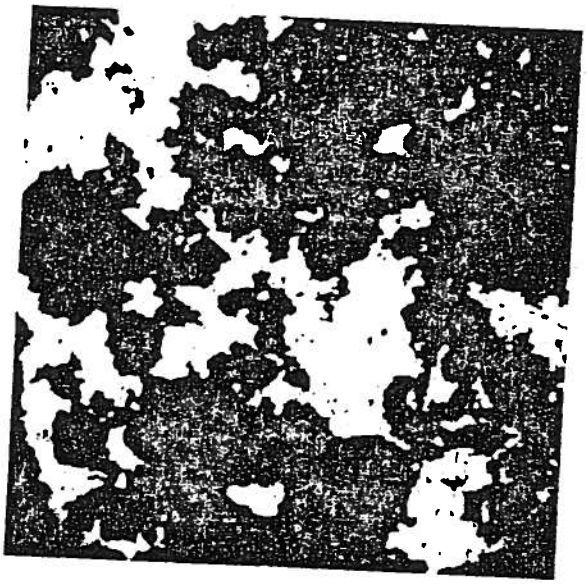

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PLATE II

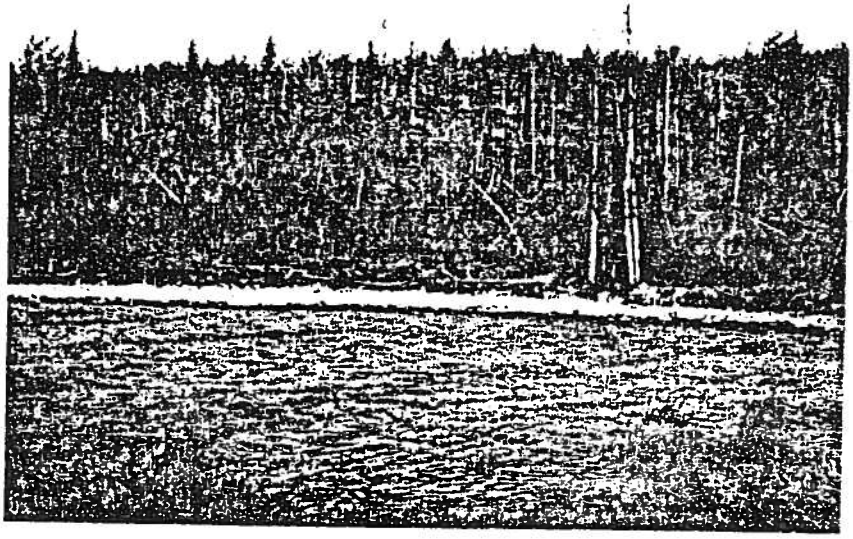
Bay Tree Deposit

Figure 1. Looking west across the deposit. Note individual for scale.

Figure 2. Looking west across the north end of the deposit. Note hummocky area at pond edge and lack of aquatic vegetation.

Figure 3. Surface sample, 125X

Figure 4. Surface sample, Chara (dark) and ostracods retained on the No. 60 mesh sieve, 20X



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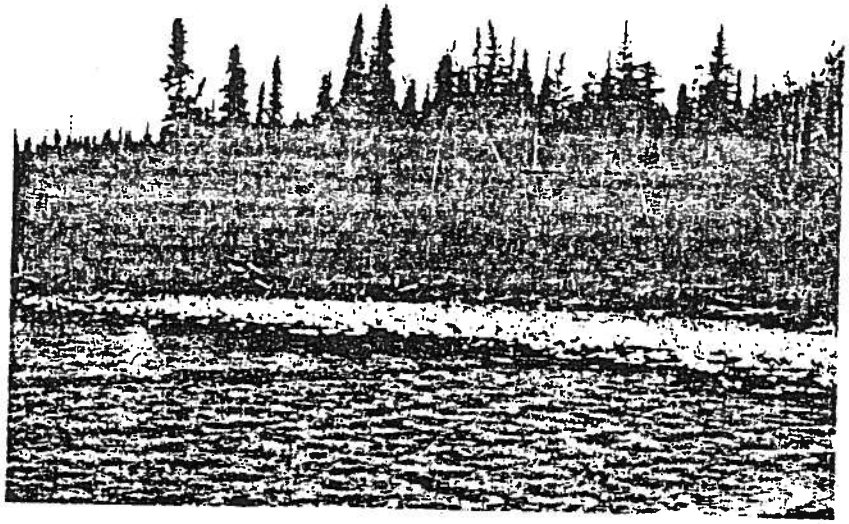

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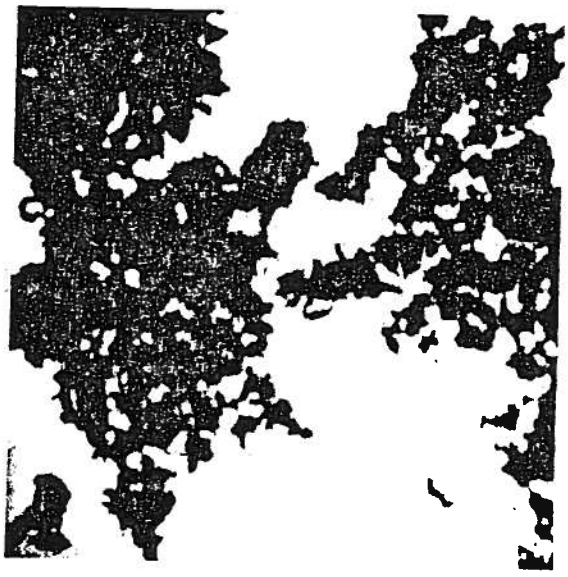

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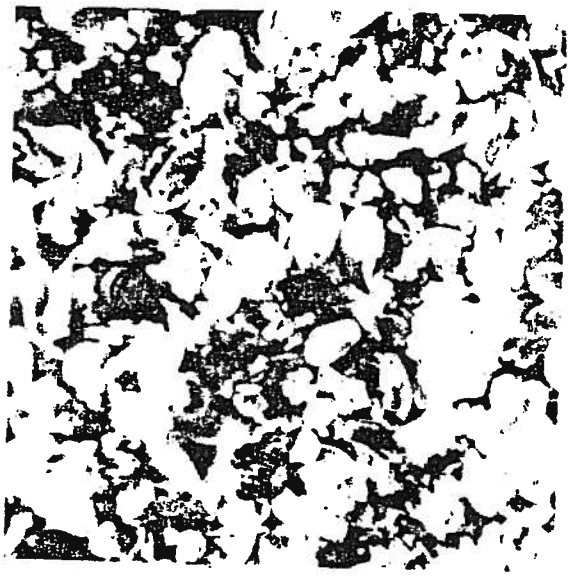

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PLATE III

Spirit River Deposit

Figure 1. Gastropod, cylindrical forms, and tufa fragments retained on the No. 45 mesh sieve, 10X

Figure 2. Marl particles (white), quartz grains (clear) and dark mineral grains retained on the No. 120 mesh sieve, 40X

Figure 3. Sample from a depth between 6 inches and 1 foot in hole 2, 125X

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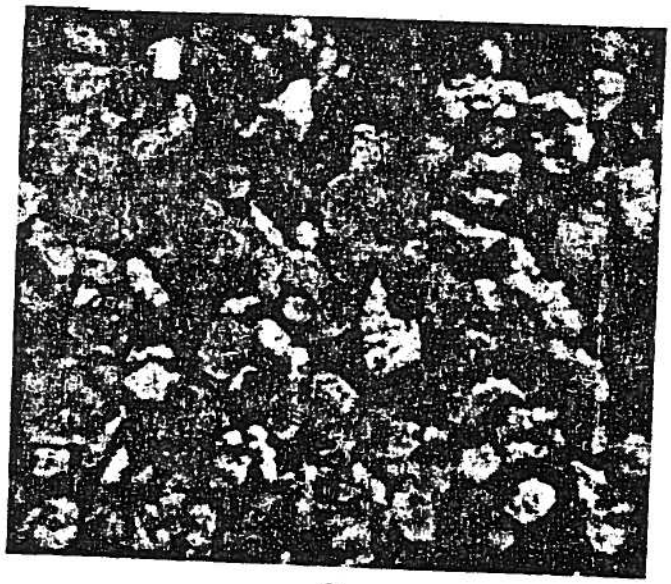

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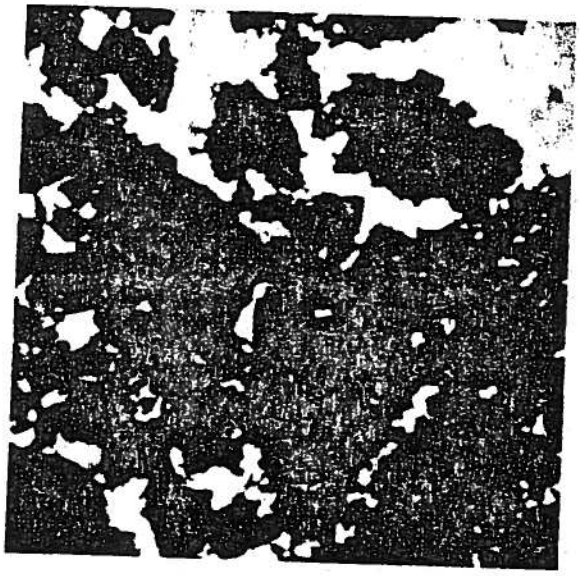

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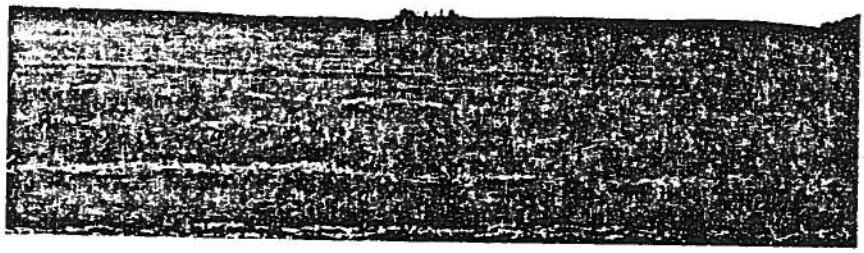
PLATE IV

Grimshaw Deposit

Figure 1. Looking south across the deposit. Mound appears on right-hand side of photo.

Figure 2. Tufa from surface at top of mound.



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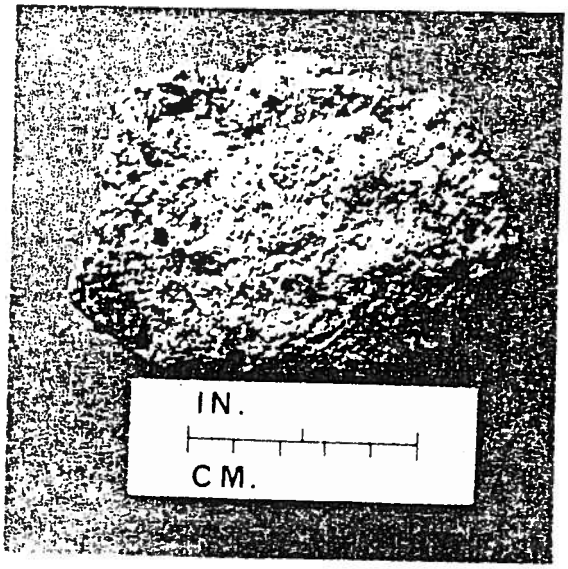

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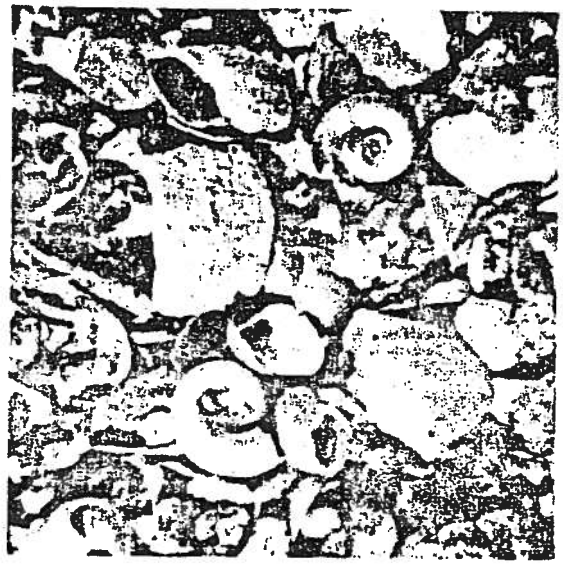
PLATE V

Grimshaw Deposit

Figure 1. Gastropods and marl particles retained on the No. 45 mesh sieve, 10X

Figure 2. Marl grains and ostracods retained on the No. 120 mesh sieve, 20X

Figure 3. Sample from hole 4, 125X



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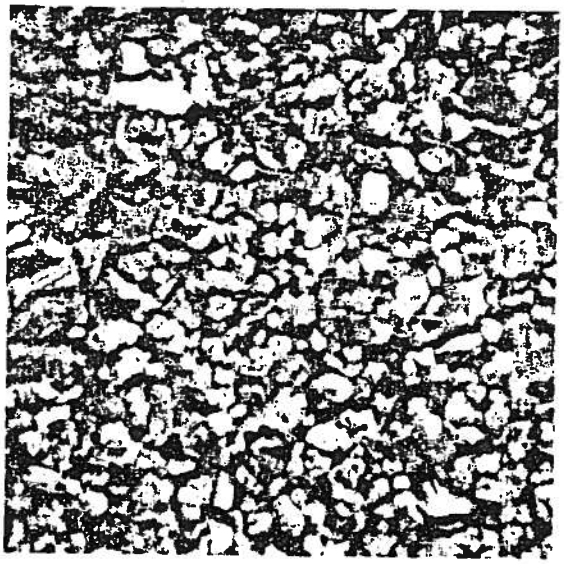

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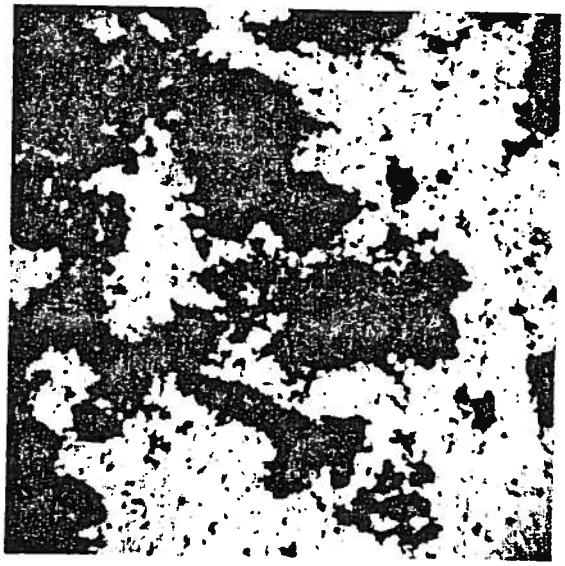

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