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Glacial Geology and Wetland Occurrence on the Tug Hill Plateau

Preliminary Report To The
Temporary State Commission On Tug Hill

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Introduction

The abundance and distribution of wetlands on the Tug Hill is directly related to the glacial drift provinces recognized by Street (1966) to the south and extended to the north by this study. The modes of drift deposition and the origins of the glacial landforms play a large role in the retention and diversion of surface and ground water, leading to wetland formation.

The central part of the Tug Hill Plateau is characterized by irregular morainal topography. This hummocky terrain grades into streamlined topography to the west and to the south (Street, 1966). The upland portion of the plateau serves as the divide between the Mohawk, Black River, Oneida, and Lake Ontario drainage basins. The upland region, located on the eastern half of the plateau, is centered about the Michigan Mills area in Highmarket. This region also serves as a boundary between the glacial drift of the Tug Hill. The drift to the east of the divide differs distinctly from that to the west, while the drift within the divide area displays a mixing of the two drift types. Street (1966) identified this mixed drift zone as an interlobate moraine (Chamberlain, 1881-82). Following Street's nomenclature, these drift zones will be referred to in this report as eastern and western segment.

Field mapping was undertaken in the summer of 1976 funded by a grant from the Temporary Commission on the Tug Hill. The purpose of the investigation was to map the surficial geology of The Tug Hill Core area and relate the distribution and properties of the wetlands to the Quaternary geology. The study area

(fig. 1) is comprised of the nine towns under the province of the Tug Hill Commission: Bolyston, Redfield, Florence, Osceola, Worth, Pinckney, Montague, Martinsburg, and Highmarket-West Turin. Surficial maps were prepared on U.S. Geologic Survey 7½ minute quadrangle maps. Figure 2 shows the location of the nine towns in respect to the quadrangle map base. The deposits shown on the accompanying surficial maps have been observed in the field, or interpreted from the topography recorded on the U.S. Geologic Survey 7½ minute topographic maps. Limited access and poor exposure, particularly in the core region dictate that the contacts shown be approximate boundaries.

Physiography

The Tug Hill Plateau embodies approximately 2000 square miles between the Adirondack Mountains and Lake Ontario (fig.3). Its eastern and northern boundaries are marked by the Black River Valley. This valley separates the Tug Hill from two other physiographic provinces; the St. Lawerence Lowland to the north, and the Adirondack Uplands to the east. The southern and western borders of the plateau are less distinct than the sharply terraced boundary of the Black River. To the south lies the Oneida Lake basin, and to the west lies Lake Ontario. The Tug Hill gradually slopes to the southwest into these areas which lie within the Erie-Ontario Lowland province. Though no distinct boundary is present between the western lowland floor and the plateau, the shoreline of glacial Lake Iroquois is customarily taken as the border between the two physiographic provinces.

Newell (1940) argued that the Tug Hill Plateau is a

Fig 1

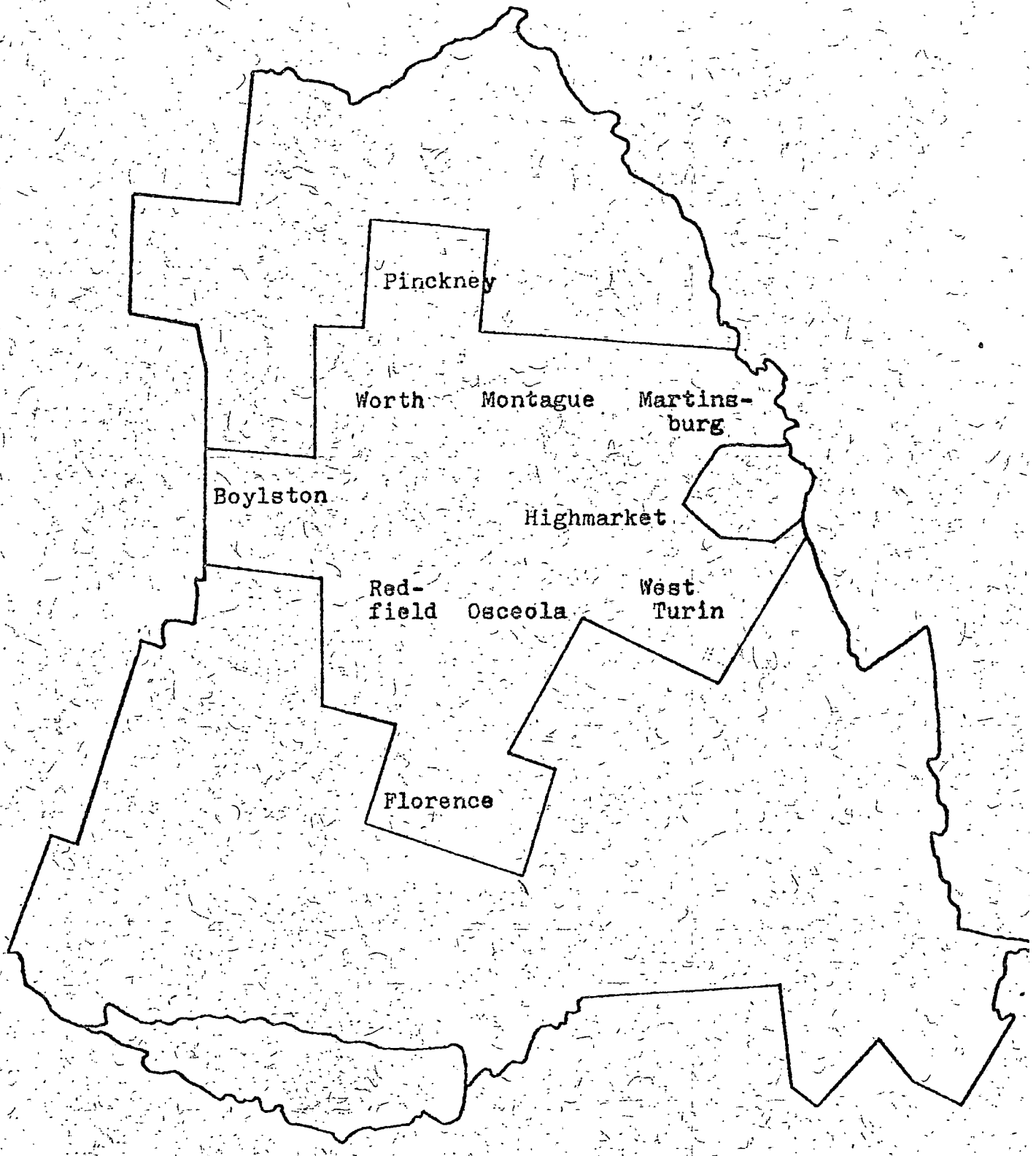
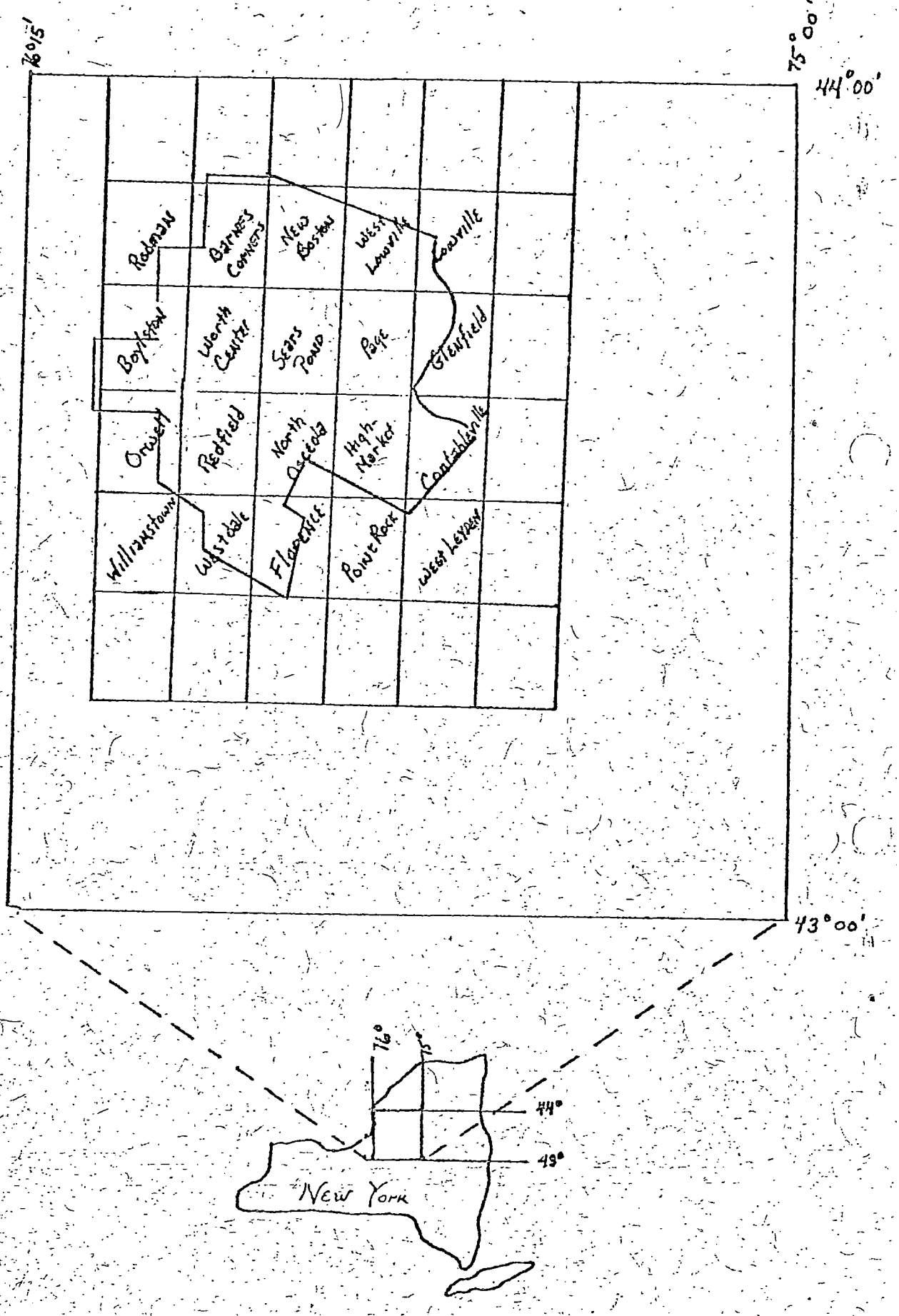

Pinckney
Worth
Montague
Martins-
burg
Boylston
Highmarket
Red-
field
Osceola
West
Turin
Florence
Study Area

Fig 2



Field Area in Regard to Quadrangle Map Base

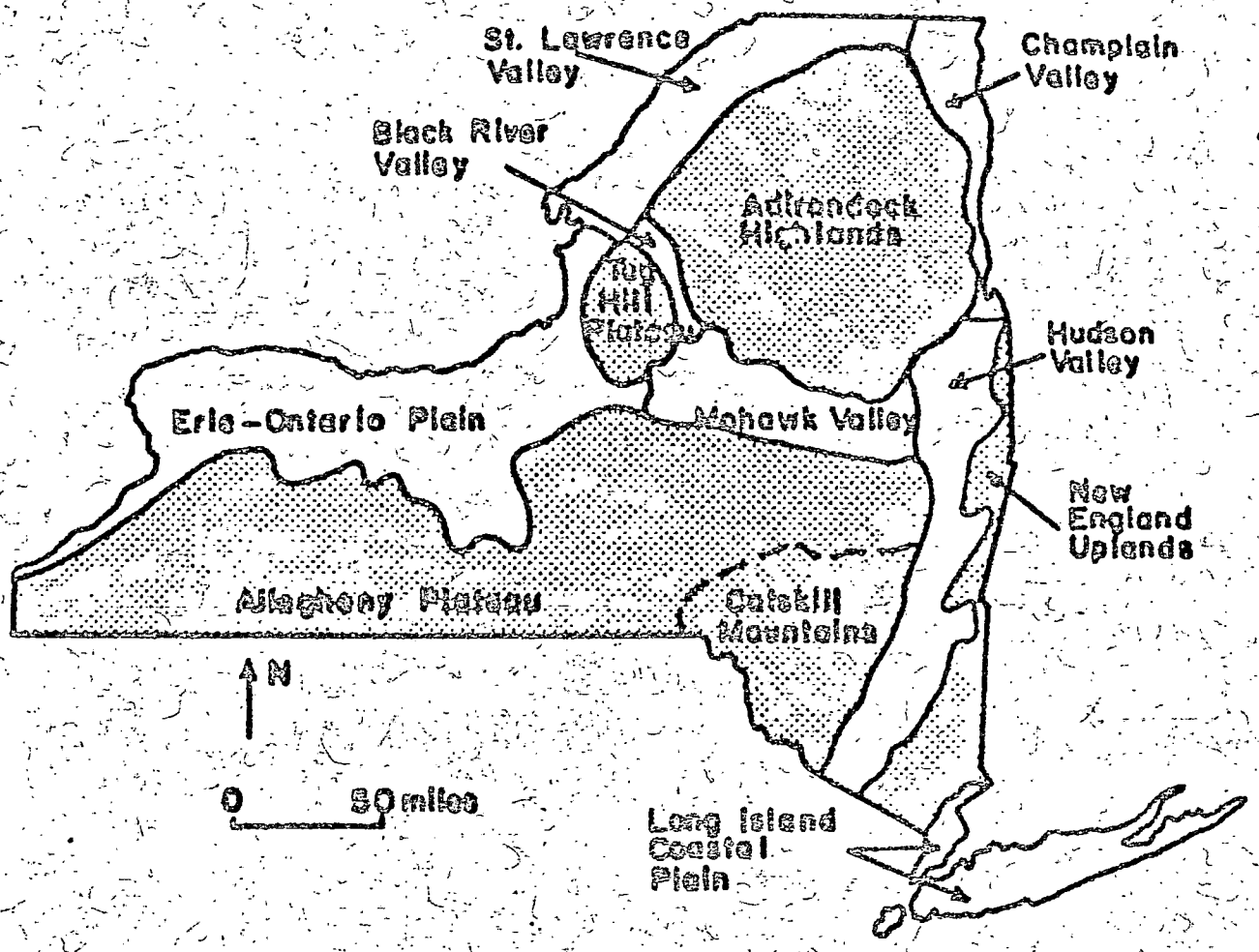


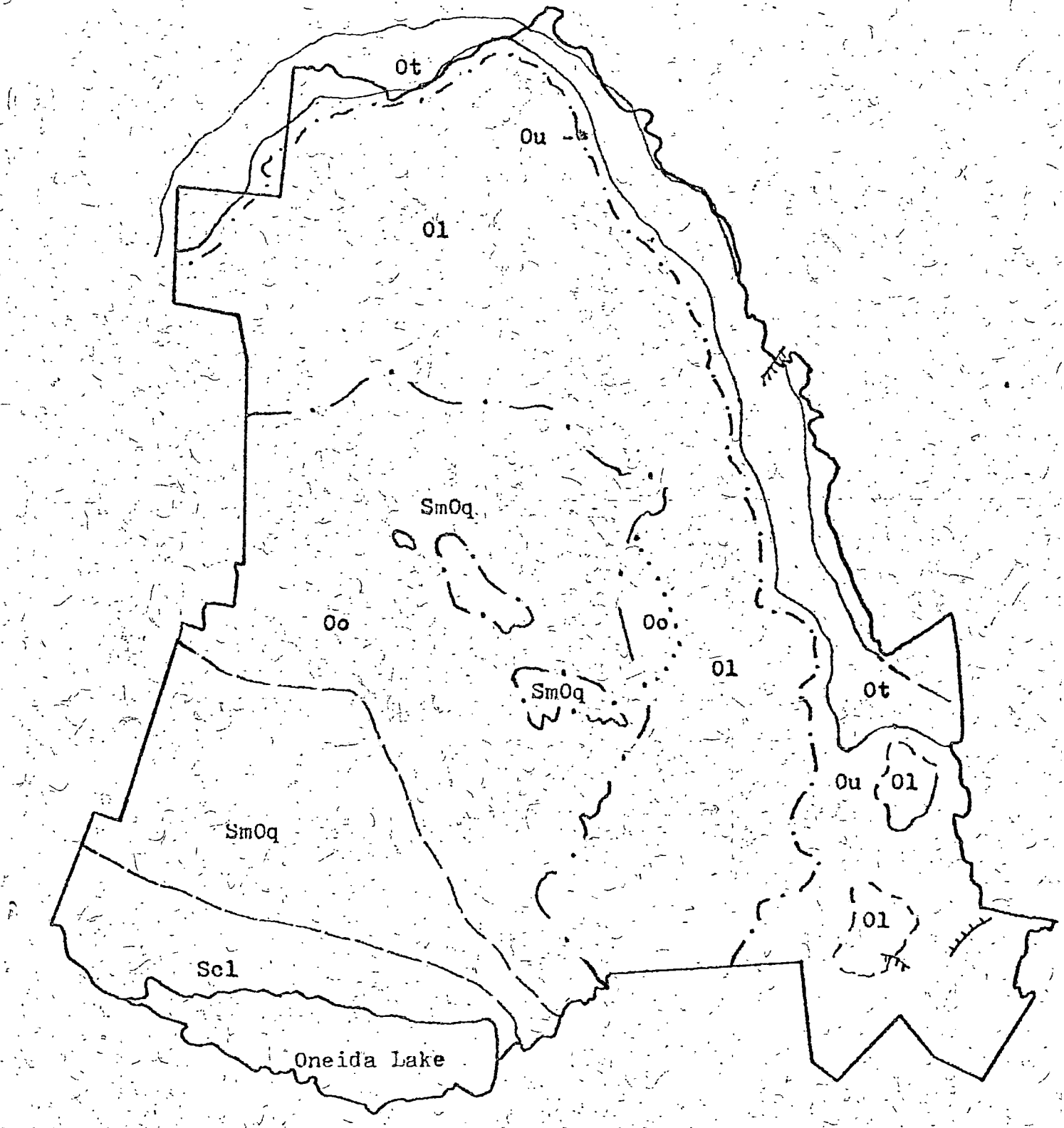
Figure 3. PHYSIOGRAPHIC PROVINCES of New York State (adapted from Olsen, 1969).

continuation of a Tertiary erosion surface from the Applachian Uplands. Muller (1964) disputed that conclusion, pointing to the structural control of the Oneida and Mohawk lowland by Silurian strata as evidence that a continuous erosion surface from the Applachian Uplands to the Tug Hill was improbable. Therefore, the Tug Hill stood as a separate physiographic province prior to the advent of glaciation. This fact plays an important role in the glaciation and subsequent deglaciation of the plateau.

Structure and Bedrock Geology

The Tug Hill Plateau is formed on Ordovician sandstone, shale, and limestone (figs. 4&5). These sedimentary beds dip gently southwestward away from the Adirondack Mountains. Structurally the beds form a cuesta[1], which owes its origin to late Paleozoic tectonics (Hanefeld, 1960). Bedrock exposures are limited due to the lack of local relief on top of the plateau, and the surficial deposits which also blanket the bedrock. Generally exposures are restricted to stream cuts. However, the eastern boundary of the plateau is marked by two bedrock scarps standing as much as 1200 feet above the floor of the Black River. The higher of the two scarps is formed in the Utica-Frankfort shale, the lower in the Trenton-Black River limestone. The bench separating the two scarp faces is developed on the upper surface of the Trenton Limestone. The best bedrock exposures

[1] assymetrical ridge whose morphology is in agreement with the dip of the strata



Bedrock of Tug Hill Plateau, after Street (1966), modified from Broughton et al (196

Explanation

Broughton et al 1962

Observed or approximately located

Conjectural, based on reconnaissance mapping

Hypothetical, projected across unmapped area

Normal fault, Hachures on downthrown side

Street, 1966

Conjectural, based on reconnaissance mapping

Figure 5 Stratigraphic Column

Quaternary			Q	Glacial and Alluvial Deposits, Bedrock Unknown
PALEOZOIC	Silurian	middle	Scl	Clinton Group
		lower	SmOq	Medina Group and Queenston Formation- Undifferentiated red sandstone and shale
	Ordovician	upper	Oo	Oswego Sandstone
			Ol	Pulaski and Whetstone Gulf Formations- shale and siltstone
			Of	Frankfort Formation- shale and siltstone Lorraine Group
			Ou	Utica Shale
		middle	Ot	Trenton Group (limestones)- Cobourg, Denmak, Shoreham, Kirkfield, and Rockland Formations
			Obr	Black River Group-Chaumont and Lowville limestones; Pamelia Formation-dolomite and limestone
			Otbr	Undifferentiated Trenton and Black River Groups
Precambrian			PG	Undifferentiated igneous and metamorphic units

are present on the eastern edge of the plateau. Small inliers of Pre-Cambrian crystallines crop out on the bench and valley floor levels in the Constableville quadrangle. These granites and gneisses underlie the lower Paleozoic sedimentary units of the Tug Hill.

The interfingering and relatively nonfossiliferous nature of the clastics creates uncertainty as to the exact nature of the stratigraphic relationships. The boundary between the Queenston Formation (Upper Ordovician and the Medina Group (Lower Silurian) can not be differentiated on the Tug Hill. The Queenston is a red shale-sandstone formation which becomes richer in the sand component to the east. The maximum shale thickness is exposed in the Niagara Gorge (Fisher, 1962), however, there is no shale fraction outcropping on the Tug Hill. This leads to confusion in distinguishing the Queenston Formation from the Medina red sandstone which stratigraphically overlies it. Broughton et al (1962) (fig. 4), have assigned the joint name Medina-Queenston to the coarse red sandstones of the Tug Hill. The Oswego Formation, a grayish-green sandstone, underlies the Queenston-Medina and interfingers with it. These two units form the cap rock of the Tug Hill. These strata in turn overlie the Utica-Frankfort formation and the Trenton-Black River limestones.

Previous Work

The Tug Hill Plateau is a relatively unstudied region. Prior to this study the majority of the geologic investigations concerning the Tug Hill were directed at its margins. Street (1966) was the only worker to carry on geologic investigations in the core region of the plateau. His work dealt with the

glacial geology on the southeastern portion of the plateau, extending as far north as Highmarket and as far west as Redfield. Stewart (1958) and MacClintock and Stewart (1963) investigated the glacial geology to the north of the Tug Hill region as far south as Sandy Creek. Glacial drift characteristics were studied by Kaiser (1938) in the Mexico area. Wright (1973) interpreted the glacial geology in the Oneida Lake basin as far east as Rome.

Until now, the glacial relationships of the core region had been extrapolations from the parimeters of the plateau. This study is the first detailed study of the central Tug Hill plateau.

Glacial Geology of the Tug Hill

Chamberlain (1885-86) argued that the Laurentide ice sheet moving southward from Canada into New York cleaved around the Adirondack Mountains and eventually overtopped that upland region. Consequently the Tug Hill Plateau at a substantially lower elevation was also buried beneath glacial ice. Subsequent workers have found evidence of a further subdivision of this lobe into an Ontario Lobe and a Black River Lobe. The advance over the western margin of the plateau by the Ontario Lobe was accomplished as the ice thickened in its southward advance. As the ice encroached over the western portion of the Tug Hill it flowed in a southeasterly direction. The local ice flow direction can be determined through analysis of drumlin[2] orientation (Muller, 1963). The Medina-Queenston and Oswego Sandstones form the cap rock

[2] elliptical hill, streamlined by glacial flow

over the western segment of the Tug Hill. These strata offered greater resistance to glacial erosion than the weaker shales and limestones exposed on the eastern segment of the plateau. Due to the structural orientation of the Tug Hill, it is probable that sandstone strata had been stripped away on the eastern segment prior to the last glaciation. This could have been accomplished by normal fluvial erosion acting on the surface of the plateau since its Paleozoic uplift, or by previous Pleistocene glaciations. Kaiser (1938) demonstrated that the drift provinces of the Tug Hill region are derived from local bedrock. The absence of Medina-Queenston and Oswego sandstone from the glacial drift of the eastern segment suggests that these stratigraphic units were absent prior to the last glaciation of the plateau. The western segment, capped by the sandstone strata (fig. 4) displays no evidence of glacially gouged or plucked (Jahns, 1943) topography. Such dramatic erosional forms as exist in the western segment owe their origin to glacial meltwater erosion which produced gorges such as Inman Gulf.

The eastern segment of the plateau reflects a more complex style of glacial erosion. Stewart (1958) proposed that the terraces adjacent to the Black River Valley are the product of glacial scour along the weaker shale and limestone strata. Jahns (1943) demonstrated that plucking action on the lee side of bedrock hills accounted for greater amounts of glacial erosion than scouring which produced polished, gentler slopes on the stoss of bedrock obstructions. The author suggests that as the Black River Lobe thickened and moved onto the Tug Hill in a southwesterly direction, it was able to fracture and pluck the weaker bedrock

units on the margin of the Black River Valley. Since a component of flow direction of the Black River Lobe was still directed to the south down the valley, scouring action produced the well defined terraces of the eastern margin.

Extent of Glaciation

Fairchild (1912) suggested that when ice began to recede off the Tug Hill Plateau it again separated into two lobes. This separation first appeared at Comer Hill, the area's highest elevation. As the ice formed into distinct lobes the Ontario Lobe was far larger in extent. In the Highmarket area an interlobate moraine formed between the two ice lobes as a distinct zone of mixing of eastern and western drift types. The approximate maximum boundary of the two lobes can therefore be taken as the north-south trending interlobate moraine in Highmarket.

Glacial Deposits of the Tug Hill

Glacial drift consists primarily of bedrock material that has been abraded, transported and deposited by glacial ice or meltwater. Drift can be subdivided into two roughly distinct types: till, which is a non-stratified sediment, and stratified drift (Flint, 1971). The two drift types are gradational compositionally and are often deposited together.

Till Deposits

Lodgement till is a compacted, predominantly unsorted deposit that is formed at the base of a glacier without the interaction of water. The absence of water as a depositional agent allows for a wide range of grain sizes in a till deposit. Characteristically, till is composed of a fine-grained matrix derived from local bedrock, and larger clasts which may range up

to boulder size. Lodgment till varies in composition from east to west, reflecting the change in underlying bedrock as well as the different flow directions of the Ontario and Black River ice lobes. The lodgment tills deposited by the southeasterly traversing ice of the Ontario Lobe were principally derived from scoured Medina-Queenston and Oswego Sandsstones. The red to greenish coloration of these western tills reflect their parent bedrock material. These tills have sand to silt size matrix and contain a small percentage of limestone clasts. The lime within the till, derived largely from the Loraine Group (fig. 4) causes cementation in some localities. The eastern drift segment is dominated by shaley-calcareous tills. The matrix and the clasts are largely derived from the Utica-Frankfort shales and the Trenton Group limestones. The increase in the shale and limestone components is accompanied by an almost complete absence of the eastern sandstone fraction. The tills of the eastern segment are gray to brown, with finer matrix than is found in the western segment. Lodgment till is widely overlain by a thin veneer of ablation till, a product of glacier wastage. This material was transported on the glacier surface and was let down onto the underlying surface as the ice mass melted down (fig. 5). Ablation till was not reworked by meltwater and as a result it also is poorly sorted as to grain size. However, since it was not emplaced at the base of a flowing ice sheet, it does not possess the compactness or fine matrix characteristic of lodgment tills.

In this report both lodgment till and ablation till are referred to as ground moraine. It is without question the most widespread deposit found on the Tug Hill.

Landforms Composed of Till

Tug Hill landforms composed of till can be subdivided into four categories: recessional moraine, ablation moraine, ground moraine, and bedrock controlled thin drift cover.

Recessional Moraine

Recessional moraines are formed when a glacier attains a temporary budget equilibrium. Advance of new ice into a region is terminated at approximately the same location by increased ablation at that location over a period of time. The material incorporated within the ice and on the ice surface is deposited at the glacier terminus forming a ridge parallel to the ice margin. Recessional moraines are approximately 40 feet high on the Tug Hill. They occur as a series of low parallel ridges usually separated by wetlands. Lodgment till is the principal component with an irregular surface blanket of ablation till. At the terminus of a glacier considerable volumes of meltwater are discharged. Therefore it is not uncommon to find spotty deposits of stratified sands and gravels associated with the ablation till. The two deposits are gradational, being distinguished on the basis of amount of water present during deposition.

The core region of the Tug Hill is dominated by recessional moraines which extend northward to Watertown and Copenhagen (Stewart and MacClintock, 1963), and to the south into Ava and Booneville (Street, 1966). The earliest moraine belt to form in the study area was the interlobate moraine in the Highmarket area (fig. 21). Several small moraines occur to the east of the interlobate region in Highmarket and Martinsburg. These moraines are oriented northwest-southeast and become younger to the north.

These maraines mark ice marginal positions of the Black River Lobe as it retreated off the Tug Hill.

Wide recessional moraine belts occur to the west of the Highmarket interlobate moraine. The Osceola and Redfield moraines mapped by Street (1966) extend to the north into the towns of Montague and Worth. The position of the eastern margin of the Osceola Moraine complex probably occurred at the same time as the formation of the smaller moraines east of the interlobate region. In Osceola and south into Florence the Osceola moraine complex reflects the protrusion of a smaller sub-lobe down the Salmon Valley. Recessional moraines in this region are oriented northeast-southwest to the south of the valley and northwest-southeast north of the valley. The orientation of the western segment recessional moraines is generally north-south away from the influence of the Salmon Trough. To the north in the towns of Pinckney and Montague recessional moraines are oriented in a more east-west direction. This alteration in moraine orientation is a product of the withdrawal of both ice lobes off of the Tug Hill and their merger into a single ice front in the Sandy Creek area as denoted by MacClintock and Stewart's correlation (1963) of these moraines to the Fort Covington Moraine. The features in Pinckney are thought to be the youngest on the Tug Hill.

Ablation Moraine

Associated with the recessional moraine ridges are zones of ablation moraine. In these areas accumulation of ablation drift was sufficiently thick as to present no one traceable moraine ridge. In some instances the underlying drumlinized topography

can be detected, but is amply blanketed by the irregular ablation moraine. Areas of ablation moraine are commonly interspersed between recessional moraine ridges and are interpreted as having formed in zones behind the recessional moraines. These areas, as in the case of the recessional moraines become younger towards the flanks of the Tug Hill. It is not uncommon to find poorly stratified gravels associated with these zones due to the effect of meltwater.

Ground Moraine

Ground moraine areas represent zones of active deglaciation, over which no equilibriun was attained in the glacier budget. As a result, these areas are dominated by southwesterly trending drumlins, reflecting the regional flow direction (Muller,1963). Ground moraine areas in the eastern segment are small due to the proximity of the Black River Lobe's maximum position with the edge of upper scarp. Ground moraine areas are common to the west of the interlobate area having been formed beneath the Ontario ice lobe.

Bedrock Controlled Drift

In restricted areas on the Tug Hill the ground moraine cover is sufficiently thin (less than 5 feet) to allow the underlying bedrock to control the topography. Some of these areas border glacial meltwater channels, where fluvial erosion was great enough to strip away the surficial material exposing or nearly exposing the underlying bedrock. The largest continuous area controlled by bedrock is the scarp faces of the eastern margin of the plateau. The nearly vertical face of the scarps was not conducive

to deposition. The balance between glacial erosion and deposition is a function of velocity, overburden and material at the glacier base (Boulton, 1974). Certain areas, particularly in Redfield and Osceola exhibit bedrock control. The explanation for that control lies within the interaction of those variables. In this report, areas which display bedrock control are mapped as "thin drift cover", indicating a surficial cover of 0-5 feet.

Stratified Drift Deposits

Stratified drift is that material which at one time was embodied on or within a glacier, but was subsequently removed by glacial meltwaters. These deposits are commonly sorted as to grain size. Stratified drift can be subdivided into two categories: ice contact stratified drift, and non ice contact stratified drift.

Ice contact stratified drift deposits are those which were deposited on top of or adjacent to the ice mass by running water. These deposits are common to the stagnating margins of glaciers, where abundant meltwater is present. Active glacial flow would overrun and destroy these waterlaid deposits, therefore they are almost exclusively restricted to stagnating glacial margins. All ice contact deposits in this report are simply mapped as ice contact. Several varieties of ice contact drift can be observed on the Tug Hill.

Kames are conical hills of sands and gravels that were deposited into impondments on the surface of stagnating ice blocks. When the ice block melted down the kame was left as a positive feature let down onto the surface of the underlying

deposits. Kames are found irregularly scattered amongst recessional moraines where active ice was more dominant. They also occur as irregular gravel knobs along the valley walls of the Salmon Trough and the West Branch Fish Creek Valley in the Westdale quadrangle.

Eskers are long sinuous ridges of glacial gravels that were formed by sub-glacial rivers emanating from the stagnation zone at the glacier margin. Eskers are found in the valley of the North Branch Salmon River. These eskers acted as the feeder tubes for the abundant gravels of the Redfield area. Similar deposits, acting in the same capacity, are found in the West Branch Fish Creek Valley. Kame terraces are also river deposits. The glacial rivers which laid these deposits down flowed between the ice margin and bedrock valley walls. Both terrace levels of the eastern margin of the Tug Hill are bounded by continuous kame terrace deposits. The material is a fine grain well sorted sand, which was deposited as the receeding Black River Lobe was trapped against the scarp faces, forming first the upper then the lower kame terrace.

Non ice contact stratified drift deposits are those sediments which have been deposited by proglacial meltwater streams. Tug Hill outwash deposits range in size from silts to gravels. Outwash areas are characterized by flat upper surfaces which gently dip away from the glacier margin. Two types of outwash deposits are present on the Tug Hill: outwash plains and deltas. Outwash plains are found in Redfield and Florence. They are composed of well sorted and stratified sands and gravels. These river deposits grade into lake deltas. The deltas are confined to the Salmon

Trough where successive glacial lakes were formed as the Salmon sub-lobe withdrew from that valley.

Mode of Deglaciation

Glacial retreat from a region commonly occurs as active-ice wastage or by mass stagnation (Caldwell, 1976). In the first case, active ice flows towards its terminus, however if ablation is greater than the supply of "new" ice the margin retreats while fresh material is still being brought to the glacier terminus. This style of deglaciation is common to the midwest where large lobate moraines were formed on the margins of the Great Lakes by temporary still stands in the glacial retreat. Stagnation of large ice masses is common to many areas of New England (Borns, 1974). Landscapes deglaciated in this manner are dominated by ice contact deposits. Jahns (1941) and Koteff (1974) have recognized an intermediate style of deglaciation between the two previous examples. They have proposed that many areas in New England were deglaciated by active ice, that had wide zones of stagnation at the terminus. The three styles of deglaciation intergrade. Any intermediate mode between an active margin, progressive stagnation, and mass stagnation is possible. Active ice brought material from the base of the glacier to the surface of the marginal stagnation zone along upward directed shear planes. A stagnation zone is usually present at the terminus of any glacier. The width of that zone greatly effects the nature of the sediment deposited at the glacier terminus. This material was then reworked by meltwater and deposited on the surface and beyond the margin of the stagnation zone. The distal edge of the stagnation zone can be recognized as the boundary between the ice contact deposits and the pro-glacial outwash.

Tracing the ice contact deposits up valley until they cease, delineates the width of the stagnation zone. This area marks the position where active ice brought fresh material up onto the surface of the stagnation zone. Although no moraine ridge was produced at this margin, it marks an active ice marginal position. Salmon River Trough exhibits several sequences of stratified drift deposits which mark the active ice margin during retreat.

The remainder of the Tug Hill was deglaciated by active ice, retreating with a minimal stagnation zone. The presence of numerous recessional moraines represent periods of equilibrium between ice advance and ablation. The relatively low elevation of the majority of these forms suggests that this equilibrium was short lived in any one specific area.

Deglacial Correlation

Glacier advance over the Adirondack Upland, recognized by Chamberlain (1885-86) has been proposed to be represented by the Malone drift south of Sandy Creek (MacClintock and Stewart, 1963). This drift has been correlated as Cary age (fig. 6), deposited by ice flowing from the Adirondack region. To the north of Sandy Creek, MacClintock and Stewart mapped moraines which they correlated with the Fort Covington Moraine of Port Huron age (fig.6). This moraine system has been traced across the northern margin of the Adirondack Upland through Copenhagen to Watertown. MacClintock and Stewart use different depths of carbonate leaching to postulate that the drift south of Sandy Creek is older than that to the north. Street interpreted that the different carbonate leaching depths on opposite sides of Sandy Creek were a

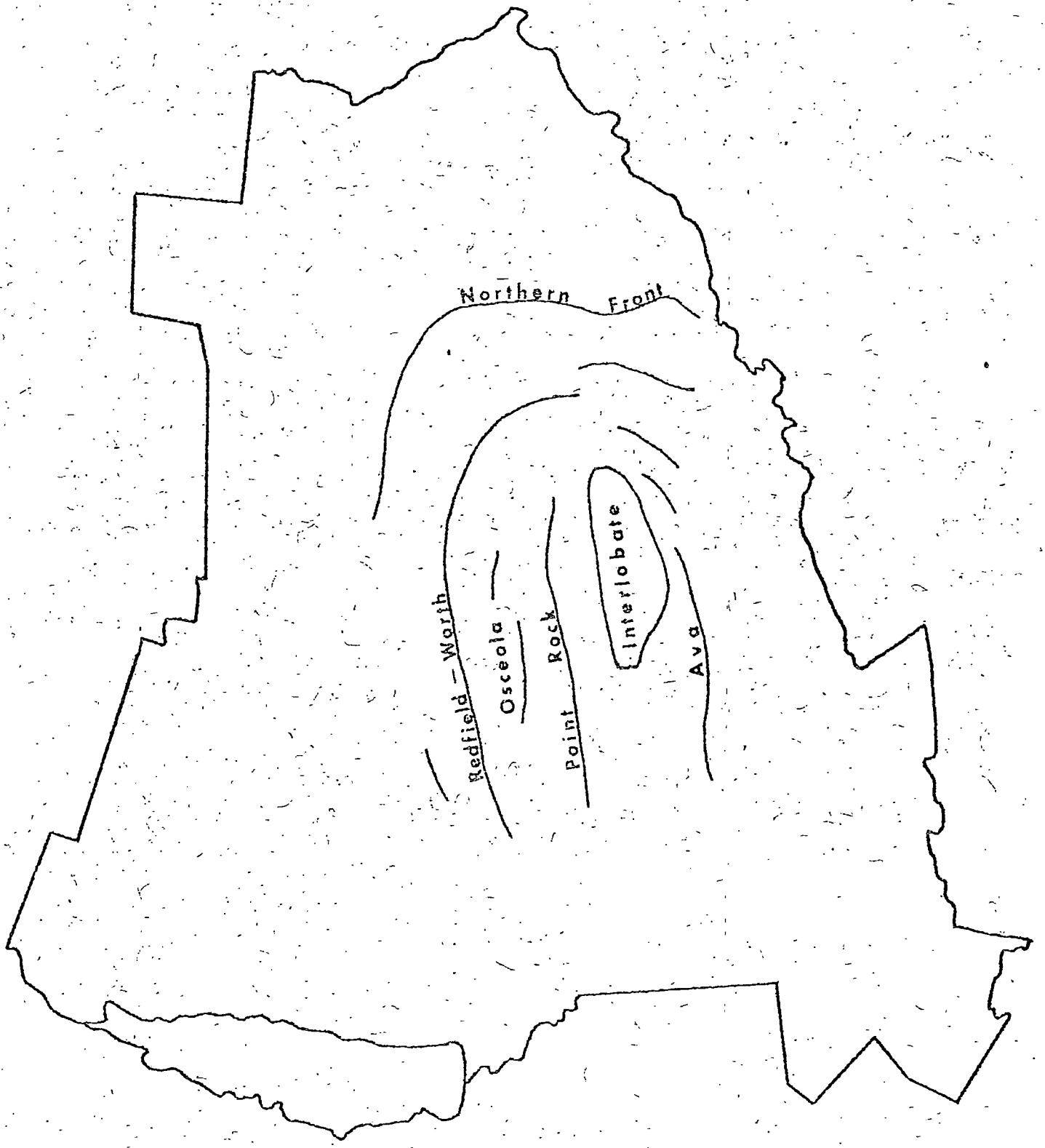
Fig. 6

Tentative Correlation of Ice Lobes and Morphostratigraphic Units in the Tug Hill Field Area

PLEISTOCENE	PORT HURON	ONTARIO LOBE	Recessional moraines in Pickney and Montague	BLACK RIVER LOBE	Recessional moraines in Martinsburg and Montague
			Redfield-Worth Moraine Complex		Recessional moraines northeast of Highmarket
			(Osceola) Moraine*		Recessional moraine in Booneville
			(Point Rock) Moraine*		(Ava Moraine)*
			Interlobate with Black River Lobe (Highmarket Interlobate moraine)		Interlobate with Ontario Lobe (Highmarket Interlobate moraine
	Valley Heads				
	Cary				

* Street, 1966

Fig 7



Recessional Moraines of the Tug Hill

function of an original difference in carbonate content in the tills derived from underlying bedrock variations. The minimum age of the Fort Covington Moraine has been established from C^{14} dates on marine fossils which overlie Fort Covington till in the St. Lawrence Lowland. However, MacClintock and Stewart's conclusion that Port Huron age ice never traversed the Tug Hill was disputed by Street (1966). He suggested that the southeasterly topographic element of the Tug Hill was not in keeping with a southwesterly Cary age flow direction. The author agrees with this objection and with Street's tentative correlation of Tug Hill deglaciation with post Valley Heads (fig. 6). Carbon 14 dates time the retreat from the maximum Valley Heads moraine position as beginning before 13,000 B.P. (Fullerton, 1976). A similar timing of the inception of glacial retreat from the maximum Highmarket Interlobate position is assumed in this study. A date between 12,000 B.P. and 11,400 B.P. is placed on the formation of the Glacial Lake Iroquois shoreline which passes through the town of Richland and Lacona (Tarasmi, 1976). These dates were obtained by C^{14} dating of post-Iroquois peat bogs. The author therefore infers a maximum date of 13,000 B.P. and a minimum date of 12,000-11,400 B.P. for the deglaciation of the Tug Hill Plateau.

The orientation of the moraine north of Sandy Creek appears to conform with the morainal orientations immediately south of Sandy Creek. Moraines in the town of Pinckney are interpreted as being the youngest on the Tug Hill.

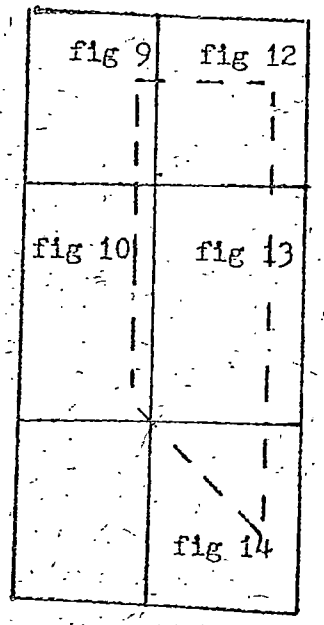
There is little evidence to suggest that glacial retreat was interrupted by readvance. One moraine outcrop east of Osceola

Center appears to be composed of prior lake bottom and outwash gravels. Although this suggests fluctuation of the glacier margin, it is felt to be of minor importance and not reflective of the overall trend of Tug Hill deglaciation.

The deglaciation of the Tug Hill was a relatively slow process, which explains the abundance of recessional moraines. Borns (1974) dates the Lexington Moraine in Massachusetts at 13,000 B.P. marking a Port Huron age advance in New England. Shilts (1970) and Caldwell (1976) suggest that northern Maine was ice free between 12,100 B.P. and 11,200 B.P. These dates are on the same order as those proposed here as maximum and minimum dates for the deglaciation of the Tug Hill. Therefore, the deglaciation of the Tug Hill is suggested to have occurred at about the same time as that of much of New England

GLACIAL GEOLOGY OF THE NINE TOWN REGION

Redfield



The town of Redfield is dominated by the presence of the Salmon River Reservoir, controlled by a dam at its western outlet in Orwell. The spillway elevation stands at 937 feet asl. Drainage north of the reservoir flows primarily through the North Branch Salmon River and the Mad River. Smaller streams like Mill and Castor also drain southward. These drainage channels occupy valleys that are deeply incised and many are too wide to have been formed under present drainage conditions. One exception to this description is the North Branch Salmon River, which occupies a broad valley.

Most of the drainage courses owe their origin to marginal glacial meltwaters discharged from the receding Ontario ice lobe. These meltwater streams flowed parallel to the north-south ice margin, following the regional slope, which decreases from 1650+ feet in the Worth Center quadrangle to less than 950 feet in the Salmon Valley. The north-south oriented channels of the Mad

River and smaller streams to the east were initiated by ice marginal rivers. These streams formed at the glacial margin and flowed parallel to the edge of the ice. These marginal meltwater channels were occupied in succession from east to west. Discharge was large but short lived, producing deep incision and prohibiting deposition within the channels. Deposition of outwash material did not occur until the swift streams encountered lower gradients in the Salmon Valley.

The largest of the marginal meltwater channels eroded the valley now occupied by the Mad River, which joins the North Branch to the north of Harvester Mill Rd. in the central portion of the Redfield quadrangle. The larger channel of the Mad River suggests that considerable discharge of meltwater was directed down its course after the glacier had receded away from this marginal position. The North Branch Salmon River differs from the other drainage channels mentioned in that it is a pro-glacial meltwater channel (Flint, 1971). It was created by meltwater flowing away from the glacier terminus rather than by marginal meltwaters. The North Branch flows in a southeasterly course through drumlinized terrain. It is not deeply incised as are the other Redfield channels, indicating more normal fluvial conditions away from the margin of the glacier. Flowing over less steep topography, the North Branch aggraded much of its own channel with outwash sediment. Whereas the north-south marginal channels emanate from a recessional moraine region (indicative of active ice movement), the North Branch formed in a zone of ablation. This is evidenced by the dicontinuous esker and kame system extending from Castor Rd.

Harvester Mill Rd. Therefore active ice was no longer present in the town of Redfield when drainage developed down the North Branch.

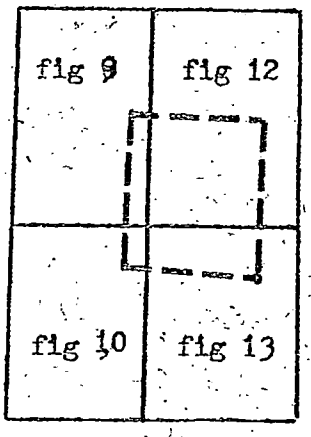
When ice flows into a valley it extends further than the glacial ice obstructed by adjacent uplands. Retreat often leaves large areas of the extended ice lobe in the valleys as drift-covered stagnant ice blocks. This process took place in the Salmon Trough as the Ontario Lobe receded westward. The thickness and undeformed nature of the sands and gravels found on the north valley wall indicate that outwash deposits carried by the marginal meltwater streams east of the Mad River, spread out over the surface of stagnant ice stranded in the Salmon Trough. The western margin of this stagnation block is marked by an outwash head (Koteff, 1974) situated in the middle of the valley to the east of the Waterburry and McCraw Rd. intersection. As active ice within the Salmon Trough receded from this margin a proglacial lake formed between the active ice margin and the stagnant ice block. The combined flow of the North Branch and the Mad Rivers flowed into this lake. Sediment deposited into this lake built out across the valley south of Redfield Center. Reversals of forset beds in a delta outcrop on the south side of the reservoir indicate that some component of the flow into this lake was from the southern valley wall.

As the pro-glacial lake deepened it overtopped its southern basin wall at an elevation of 940 feet asl. and flowed southward down the Mad River. This discharge is recorded in the outwash river gravels to the south of the reservoir. The lake drained

through the Mad River until the receding ice opened a lower drainage outlet of 900 feet asl. at the western end of the lake. Discharge was then directed to the west creating the Salmon falls.

East of the North Branch the topography is markedly different than that in the northern portion of Redfield (Redfield and Worth Center quadrangles). In the north, deglaciation by active ice produced recessional moraine topography. Ablation moraine overlying drumlinized topography dominates the eastern portion of Redfield. The different styles of deglaciation are responsible for the difference in drainage channel orientation from east to west.

Boylston



The town of Boylston displays markedly different surficial geology than the towns located to the east. Two localized drainage directions are observed, both dictated by the glacial geology.

The eastern portion of Boylston is blanketed by a wide zone of ablation moraine. This ablation region is contiguous with mapped ablation moraine in western Worth and northwestern Redfield. The western boundary of the ablation moraine in Boylston is approximately delineated by Vorea Rd. to the south of Boylston Center. Large quantities of ablation till mantle the observed underlying drumlins. The irregular pitted surface of the drumlins is the product of this ablation cover. Interdrumlin areas are discontinuous, many contain wetland basins (Tamarack Swamp). The drainage within this zone follows a southwesterly course through the interdrumlin lowlands.

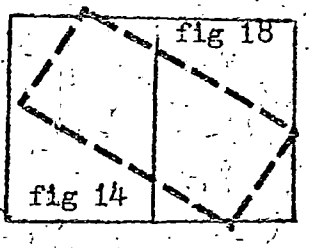
To the west of Boylston Center the surficial cover is variable (0-40 feet). Drumlins are not recognizable due to

dissection of the topography by deeply incised channels. These channels trend to the southwest and are observed throughout the western portion of Boylston. This trend is not conformable with the evidence of a north-south ice margin as indicated by the orientation of recessional moraines in southern Worth and northern Redfield. Nor is it conformable to the overall northwesterly retreat of the glacier from the western part of th Tug Hill, indicated by the northeasterly trending moraines in the Sandy Creek region. A possible explanation for these parallel channels is that they are structurally controlled, flowing in a bedrock joint system. They probably formed as marginal meltwater channels, but redirected their flow beneath the glacier margin (Sissons, 1960).

Ice-contact stratified drift deposits are associated with the channels in western Boylston. Eskers and kame deposits line most of the channels. Currently under excavation is an esker deposit in one of these channels along McKibbens Rd. The esker was produced by a confined subglacial stream aggrading its own channel. The western edge of Boylston is marked by kamic gravel deposits along the channel walls. Deposits of this nature can be observed in several of the channels intersected by Van Aucken Rd. They were deposited an subglacial channels emerged onto the surface and, no longer confined, spread out depositing their load.

The majority of the surficial cover, however, is lodgment till. Exposures of a red, silty, compacted lodgment till are found along Hart Rd. This till is characteristic of the western zone of the Tug Hill.

Florence

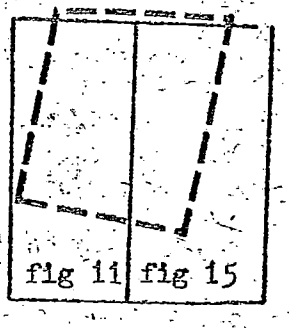


The town of Florence displays a series of recessional moraines oriented northeast-southwest, which are superimposed atop drumlin topography. The orientation of the moraines (figs. 14 & 18) reflects the dominance of the Salmon Trough in the southwestern portion of the field area. The ice extended further into the valley than in the uplands. While the marginal zone within the trough often calved leaving stagnating ice blocks in the valley, the upland continuation of the glacier remained active. The margin of the ice adjacent to the trough formed a northeasterly trending front to the position where it joined the extended sublobe within the Salmon Valley. As the ice receded several moraines exhibiting this orientation were formed in Florence to the south of the trough. The crest of the upland region is approximately marked by the northern town line of Florence. Street (1966) suggested that the area between the Salmon and West Branch Fish Creek Vallies, was deglaciated more rapidly than the two vallies.

This deglaciation trend developed as a product of sub-lobes of the major Ontario Lobe extending into these vallies. Similar development of stratified drift morphological sequences (Koteff, 1974) occured in the West Branch Fish Creek Valley as were produced in the Salmon Trough. The primary source of material was again from the north following the regional slope. Elevations decrease within the town from 1300+ asl. in the northwest to below 66 feet asl. in the valley. The relationship of the morphological sequences found here is unclear with respect to the deglaciation of the remainder of the Tug Hill. The deposits range between 600-650 feet asl. Moraines of this elevation were deposited by the Stanwix readvance (Kraull, 1973) in the Rome area. At the present time Chambers (in draft) is developing the relationship between these deposits and the deglaciation of the Oneida Sub-lobe to the south.

The course of the Mad River in the northern portion of Florence contains outwash gravel deposits. These were deposited when the 940' asl. spillway was uncovered on the southern wall of the Salmon Trough. The proglacial lake drained south through that spillway. These deposits of outwash postdate the recessional moraines, not having formed until the active ice margin stood well to the west of the Mad River.

Pinckney

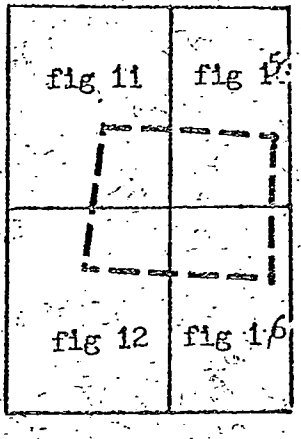


Pinckney lies to the north of Worth and Montague, and displays a continuation of the recessional moraine complex present to the south. Recessional moraine belts are separated by zones of ground moraine. The ground moraine varies in thickness from 0-10 feet. Inman Gulf and Sandy Creek form in the western part of the town and rapidly become deeply incised, westerly trending channels. These channels, like those described in Redfield owe their origin in part, to marginal meltwaters flowing at the glacier terminus.

An alteration in the orientation of glacial features in this northern district suggests that the Ontario Lobe was no longer prominent over the Tug Hill. Rather, an ice front without major lobation was developing across the northern portion of the plateau. To the southeast, a wide zone of ablation moraine was formed by stagnation and retreat of the glacier terminus in Boylston. The recessional moraines progressively change in orientation from northeast-southwest to east-west in a west to east trend in the

town of Pinckney are interpreted as still displaying the effect of the waning Ontario Lobe, while those to the east are felt to be more the product of a northern ice border. Development of this actively deglaciated region and of the ablation moraine and channeled zone in Boylston are interpreted to be synchronous. Therefore, active ice separated from stagnating ice to the south, in the Inman Gulf area. This produced recessional moraines in the north, while ice contact deposits were forming in Boylston through stagnation.

Worth



The township of Worth is located to the north of Redfield. Their shared border also forms the boundary between Oswego and Jefferson Counties. The recessional moraine region of northern Redfield extends into Worth, and is representative of most of that towns landscape. Worth is characterized by low hummocky relief. The low relief ridges common to the town are principally composed of a very compact, silty lodgment till similar to that found at the Wart Rd. location in Boylston. A notable difference between this recessional moraine zone and its extension to the south in Redfield, is the presence of greater amounts of ablation till on the surface. Areas of greater ablation cover within the recessional zone are identified in the accompanying maps by the symbol (R_a). The ablation symbol (a) is simply descriptive of increased ablation material within the recessional moraine and is not to be confused with ablation moraine (A).

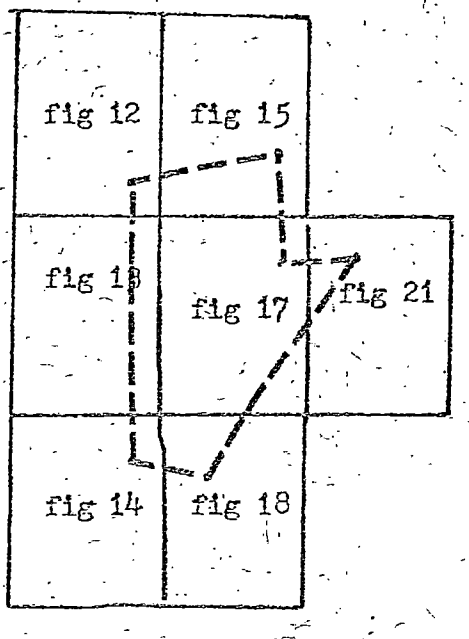
No major Pleistocene channels were developed through Worth.

This is a function of the small moraine ridges, which successfully interrupt any continuous drainage line, and a limited drainage area near the apex of the Tug Hill. Impondment on the surface of Stagnating ice blocks produced small kames interspersed through the recessional moraine. These deposits are poorly sorted and stratified, and many contain abundant angular rock fragments. The poorly washed character of these deposits suggests that meltwater was limited during their development.

In the northern portion of Worth, located in the Barnes Corners quadrangle (fig. 11) the recessional moraine ridges curve around to a northeast-southwest orientation, indicating retreat to the northwest simultaneous with retreat to the west indicated by the north-south moraines of southern Worth and northern Redfield.

The western portion of Worth in the Boylston Center and Rodman quadrangles (figs. 8 & 9) reflect a change from recessional moraine to ablation moraine to ground moraine. Thus when the glacier retreated into the area now occupied by the Littlejohn State Game Management Area it had developed a wide stagnation margin on the plateau's western edge. This region became a zone of ablation moraine, continuous to the south in Redfield and to the west in Boylston. Ablation moraine zones are commonly found on the ice proximal sides of recessional moraines throughout the Tug Hill. The northwest portion of the town is dominated by ground moraine without any conspicuous topography indicating and active, relatively constant retreat with minimal stagnation.

Osceola



Osceola lies to the east of Redfield and is located within the core of the Tug Hill. Access is limited due to a lack of road coverage, and surficial exposures are rare due to the heavily wooded nature of the terrain.

As in Redfield, two distinct styles of deglaciation can be observed within the town of Osceola. The morphologic sequential deposits of the Salmon Trough indicate a number of ice marginal positions. The eastern and northern portions of the town are occupied by broad recessional moraine zones. The eastern tip of Osceola extends into the Highmarket quadrangle (fig. 21). The recessional moraines formed in this locality are continuous to the south into Point Rock. Street (1966) indicated that this moraine complex was the first formed by the Ontario Lobe after its recession from the Highmarket interlobate region. The Osceola moraine belt was formed directly to the west (fig. 17) of the Point Rock moraine. The two moraine zones form a continuous east-west feature in the northern sections of the town. Osceola

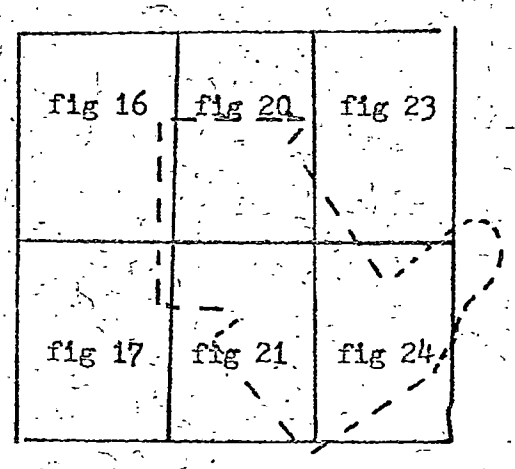
exhibits broad zones of recessional moraine to the north and south of the Salmon River. These moraine complexes were produced solely by the recession of the Ontario Lobe. The composition of the material is similar to that in the more western towns. A decrease in the Medina-Queenston sandstone fraction is accompanied by an increase in the Oswego sandstone component in the lodgment tills. The resultant soil coloration is not as red as in Redfield or Boylston.

Two ice-marginal positions are clearly marked within the Salmon Trough. The older position is located east of Osceola Center at the Salmon River Cemetery. A thirty-foot streamcut exposes a till composed of overrun outwash gravels and lake sediments. These sediments protrude slightly from the south wall of the Salmon Valley. Across the valley, kame deposits on the northern valley wall terminate opposite the cemetery. This position across the valley marks a complex moraine site. The moraine position is described in part by a morphological sequence deposit (kames) and in part by a recessional moraine (cemetery stream cut). To the west of Osceola Center a second moraine is observed transverse to the valley. Two large ridges of lodgment till protrude from both valley walls. The size of this moraine, when compared to the moraine site at the cemetery suggests an ice marginal position of longer duration. After its deposition, the moraine was transected by easterly flowing glacial meltwaters. These meltwaters formed a pro-glacial lake (predecessor to the proglacial lake in Redfield), imponded between the ice to the west and the uplands to the east. The lake overtopped its basin at 1300+ ft.

feet asl. and flowed southeasterly through the Leisure Mill area. Initial flow was to the east, followed by enough ice recession to uncover a lower southerly outlet. This outlet was rapidly succeeded by lower spillways to the west at 1240 and 1220+ feet asl., as the ice receded westward uncovering the outlets at lower elevations. The proglacial lake remained confined within this basin until the Mad River outlet was uncovered in Redfield.

To the north of the Salmon Valley, ice-contact and outwash gravels suggest that stagnation had occured. Small deltas were built into minor impondments, indicating that free drainage to the south was impeded by an extended ice lobe within the valley. These deposits northeast of the town center predate the formation of the large moraine in the valley, west of the center.

Highmarket-West Turin



Highmarket-West Turin is a unique region with respect to its surficial geology. The central portion of Highmarket is characterized by low irregular ridges. These ridges are of lower relief than the recessional moraines observed on the west. This zone of low relief ridges marks the Highmarket Interlobate moraine (fig. 21). An east-west traverse from just west of the Highmarket Church to Michigan Mills reveals a change in the composition of the glacial drift. The interlobate region is composed of drifts common to the western segment as well as drift native to the eastern segment. The east-west change across the interlobate belt from a limestone shale lodgment till to a sandstone-silt lodgment indicates the areal distribution of the two ice lobes. The interlobate moraine trends north-south throughout the entire length of Highmarket and extends southward into Lewis.

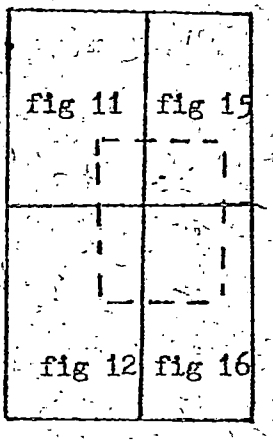
The western portion of Highmarket is characterized by drumlin topography onto which recessional moraines of Ontario

Lobe drift have been built. The western Highmarket moraines are continuous to the south through Osceola and into Lewis (fig. 21).

The majority of the glacial features in Highmarket-West Turin owe their formation solely to the Black River Lobe. East of the interlobate region the topography is gently rolling and of variable drift thickness. The ground moraine is interrupted by a few small recessional moraines near the crest of the upper escarpment. The eastern portion of Highmarket-West Turin is dominated by the east facing scarps of the cuesta-form landscapes adjacent to the Black River. Bedrock control of the landscape is dramatically evident along the entire eastern margin of the plateau. In general, the scarp faces as well as the bench which separates them have only a thin cover of glacial drift. Kame terraces are found along the bases of the upper shale and lower limestone scarps. The bench level which separates the two has a lodgment till veneer. Locally, postglacial shaley alluvium has been deposited over the till by streams flowing off the plateau. The deeply incised channels of the upper scarp were produced in part by large volumes of glacial meltwaters pouring down off the plateau surface.

The eastern portion of Highmarket-West Turin contains the Black River. A well developed flood plain can be observed as well as older flood plain deposits at a slightly higher elevation.

Montague



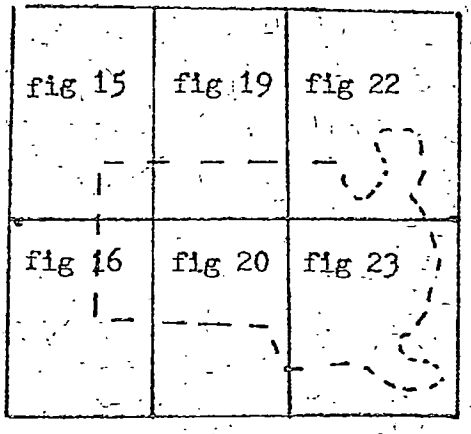
Montague exhibits a transition of surficial features from north to south. Montague lies to the northwest of the Highmarket Interlobate moraine. The southern and northern portion of the town are occupied by wide recessional moraine belts (figs 16 & 17), contiguous with the observed morainal zones in Worth and Osceola. The north-south trend of the moraines indicates a similar ice frontal orientation with ice retreat generally westward

The northern segment of Montague (figs. 15 & 17) reflects thr trend towards a single east-west oriented ice front. The recessional moraines across the northern section connect the northeast trending moraines in northern Worth and the north west oriented moraines in northern Martinsburg. Thus, as the two lobes retreated from the Highmarket region, a stationary ice margin developed across northern Montague.

The glacial drift in Montague resembles the eastern segment more than the western segment. This is a function of the outcrop

pattern to the north (fig. 4), rather than dominance of Black River Lobe drift.

Martinsburg



Martinsburg encompasses parts of six quadrangles, and in doing so, exhibits a variety of surficial geology. The Black River Valley with its step-like terraces dominates the topography and the corresponding glacial geology in the eastern portion of the town. The topography above the upper scarp becomes morainic on the plateau surface. Some of the most spectacular scenery on the Tug Hill is found on the upper scarp face where meltwater streams incised deep channels into the bedrock at Whetstone Gulf and Roaring Brook.

The town lies largely to the northeast of the Highmarket Interlobate moraine. Its surficial geology therefore, was produced by the Black River Lobe. When separation of the two ice lobes took place in Highmarket, the Black River Lobe had a much shorter distance to retreat off the Tug Hill than the larger Ontario Lobe. The Black River Lobe originally had a much shorter distance to flow onto the plateau in this area, hence, it was able to attain dominance over the Ontario Lobe.

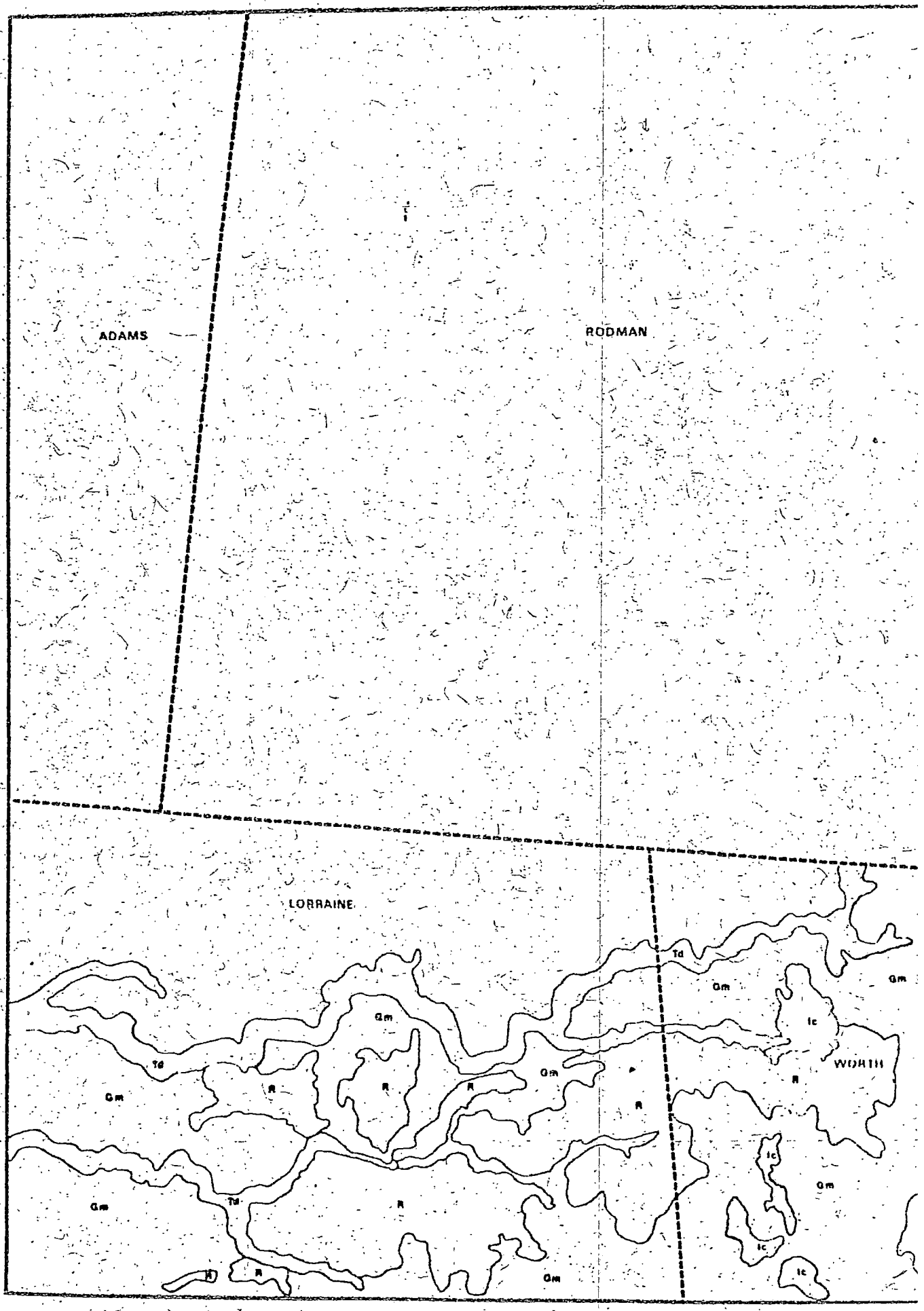
The wide zones of recessional moraine common to the western segment are absent in the eastern segment. Martinsburg, however, offered a larger area surface to the northeast than the Highmarket region to the south, over which the Black River Lobe retreated. In Highmarket the northeastward retreat of the glacier was not recorded by moraine formation due to the short distance between the interlobate region and the crest of the plateau. In Martinsburg the scarp face had developed a more gentle slope. The southwesterly advancing Black River Lobe overtopped the plateau in this area prior to the more southerly regions. Glacial scouring and abrasion was more focused in this region, thereby reducing the slope of the upper scarp. The reduced slope allowed for a slower retreat across the northeastern section of Martinsburg than the towns directly to the south. As a result, several small recessional moraines, exhibiting a northwest-southeast orientation (fig. 19), developed at the ice margin across the northeast portion of Martinsburg. The orientation of recessional ridges becomes increasingly east-west along the town's northern border in the direction of Montague. This observation suggests the presence of a single ice front in this region rather than distinct lobes. The southeastern corner of Martinsburg is occupied by recessional moraines contiguous with the (Point Rock)' moraine in western Highmarket. This is the only area in Martinsburg which displays Ontario Ice Lobe features.

On the plateau surface throughout Martinsburg, the recessional moraines are separated by wide zones of ground moraine. Lodgment till, mostly less than 10 feet thick, with a minimum of ablation cover predominates in the western zone drifts. The till

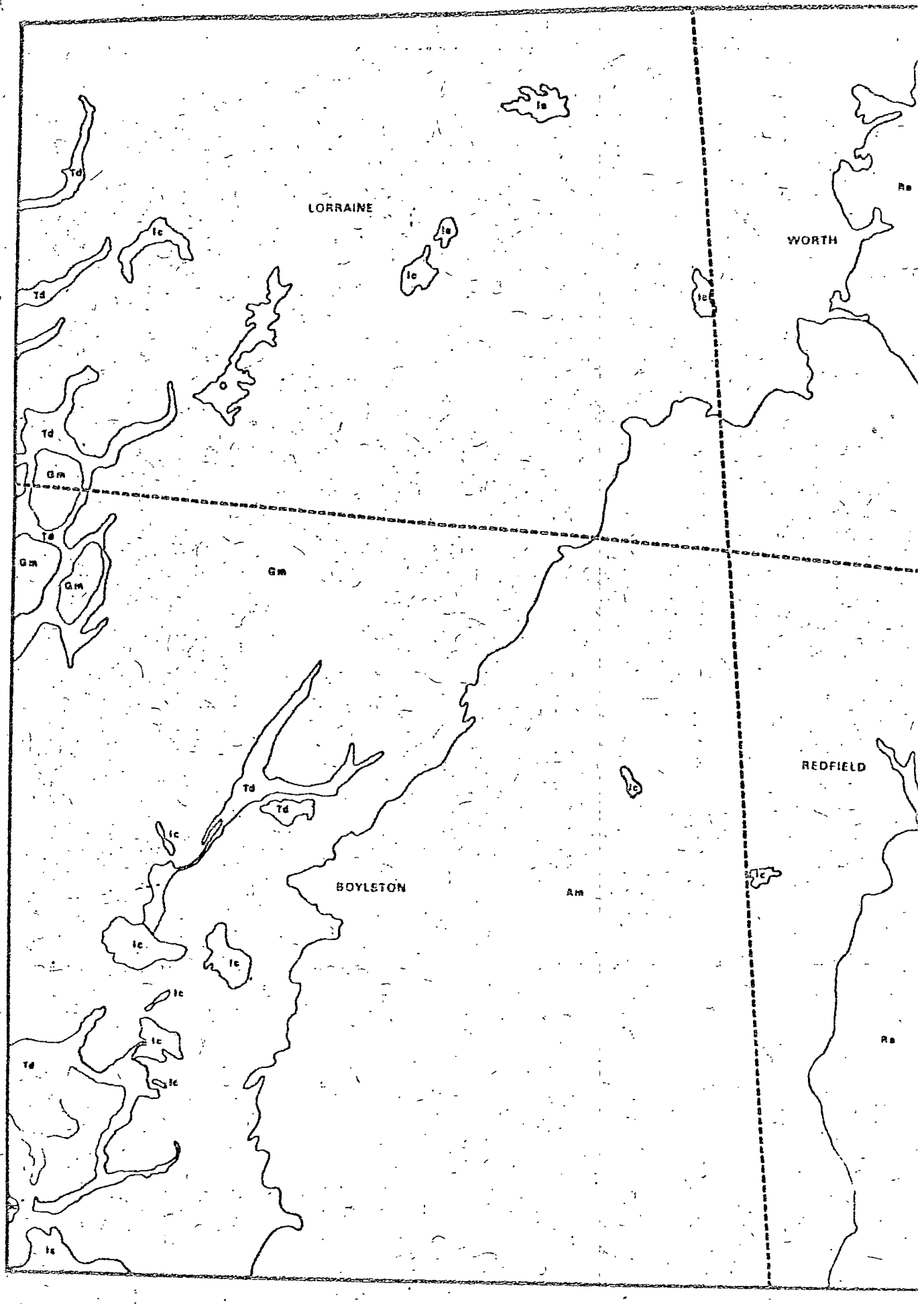
has a limey-clay matrix which displays strong fissility. This material is extremely compact and impermeable. The kame terraces observed in Highmarket-West Turin are present at the base of both scarps in Martinsburg. Ice-contact deposits are typically composed of gravels, however these deposits are almost exclusively fine sands. The fine grained nature of the underlying bedrock and the abrasive scouring of the bedrock by the glacier are indicated by the composition of these kame deposits. As in the south, both scarp faces and the intervening bench are controlled by bedrock with only a thin veneer of Black River lodgment till.

EXPLANATION

Unit	Feature	Surface Expression	Materials
R	Recessional moraine	Straight to arcuate ridges, 10-50 feet high, 50-300 feet wide, up to 2 miles long	Variable, principally lodgement till ablation till and ice-contact gravel
Ra	Recessional moraine with ablation cover	Ridges, undifferentiated, hummocky	Lodgement till overlain by thick ablatio till with interspersed ice-contact gravel
Ri	Interlobate moraine	Discontinuous ridges, generally less than 20 feet high	Till, composition grades from clay matr to sand matrix from east to west
Gm	Ground moraine	Blanket deposit, surface topography irregular, often drumlinized	Till, mixture of boulders, sand, silt, and clay, compact and fissle
Am	Ablation moraine	Irregular accumulations mottling the surface of drumlins, found on drumlin ridges	Ablation till, with some ice-contact gravels
Td	Thin drift cover	Reflects underlying bedrock surface	Thin deposits of till, generally less than 5 feet thick, bedrock outcrops numerous
O	Outwash	Flat topped surfaces found on valley floors	Well sorted and stratified sand and gravel, coarser near head of morphological sequenc
Od	Outwash delta	Flat topped surfaces grading into valley bottoms	Fine sands, displaying well developed forset be
Ic	Ice-contact washed drift	Variable ridges(eskers), flat terraces(kame terraces), Isolated conical hills(kames)	Gravels and sands, poor to well sorted
Gl	Glacial lake sediments	Generally flat	Fine sand and silt lake sediments
A	A_1 Older Flood Plain A_2 Present Flood Plain	Generally flat	Variable, sand-silt with some organic matt
Qa	Quaternary alluvium	Confined to interdrumlin lowlands	Variable, silts, fine sand with some organi matter, largely derived from slope wash
O/I	Outwash overlying ice-contact deposits		
I/A	Ice-contact deposits overlying till deposits		
R/T	Thin recessional moraine cover overlying bedrock		

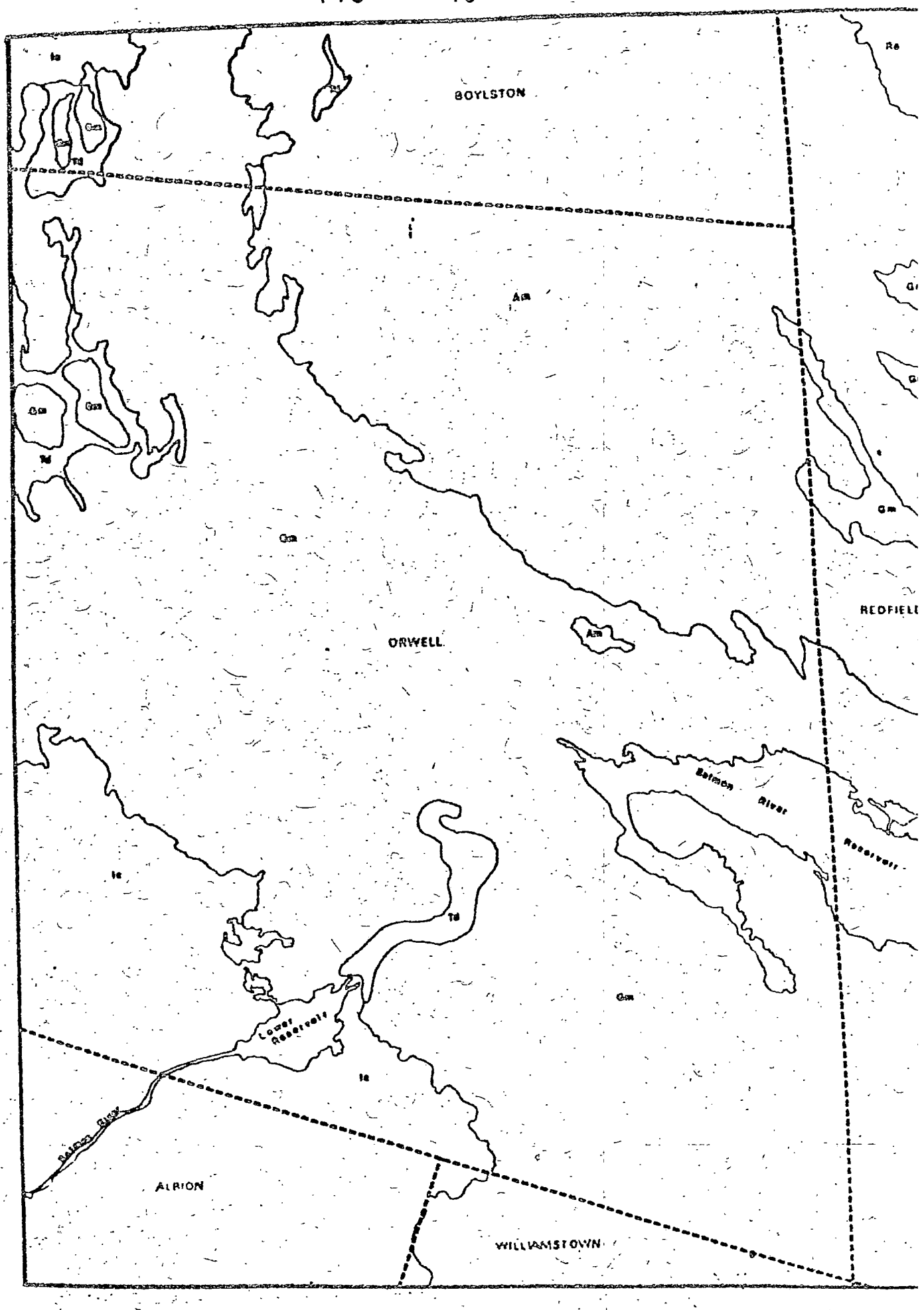


Rodman



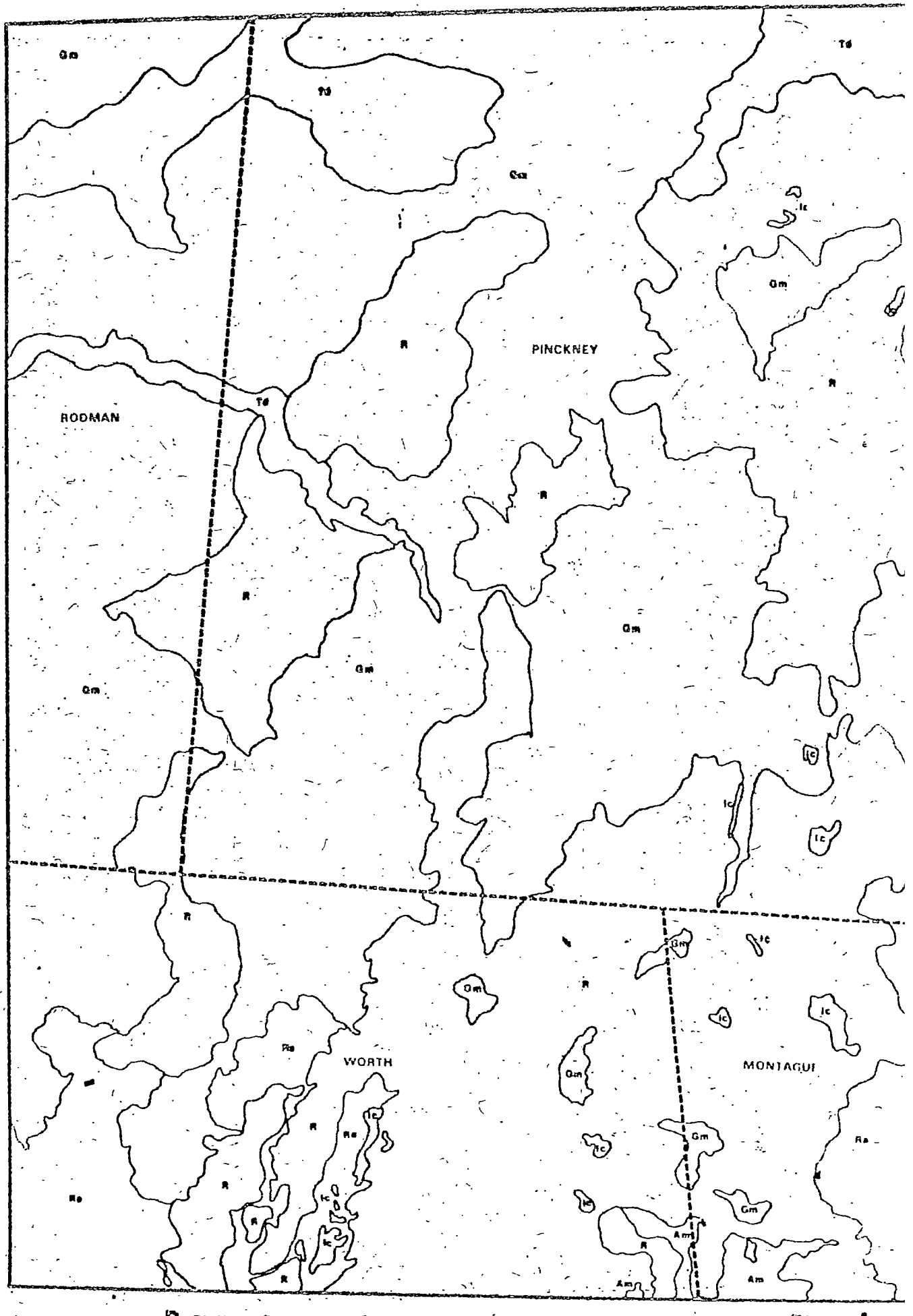
Boylston Center

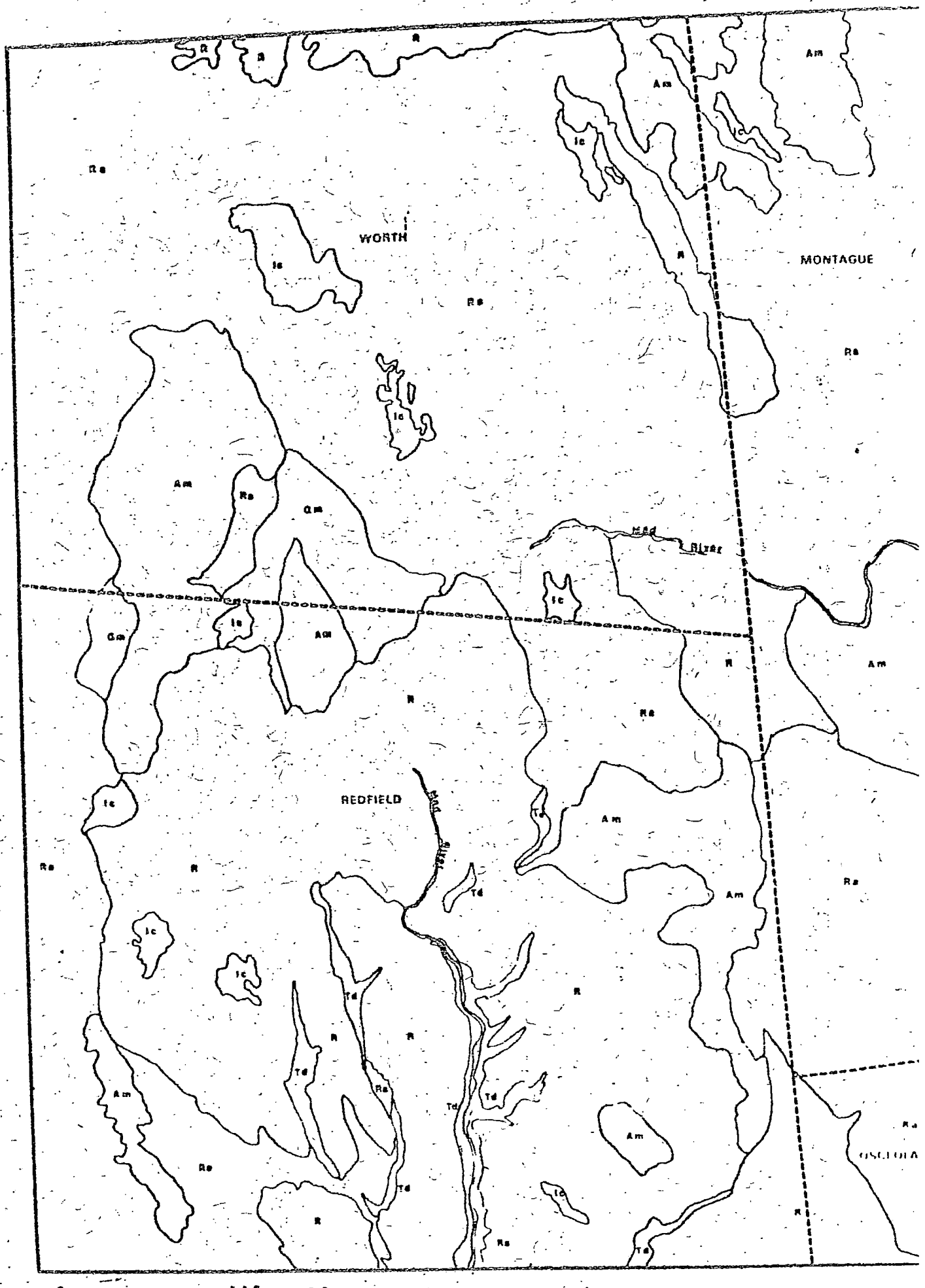
FIG 10



Orwell

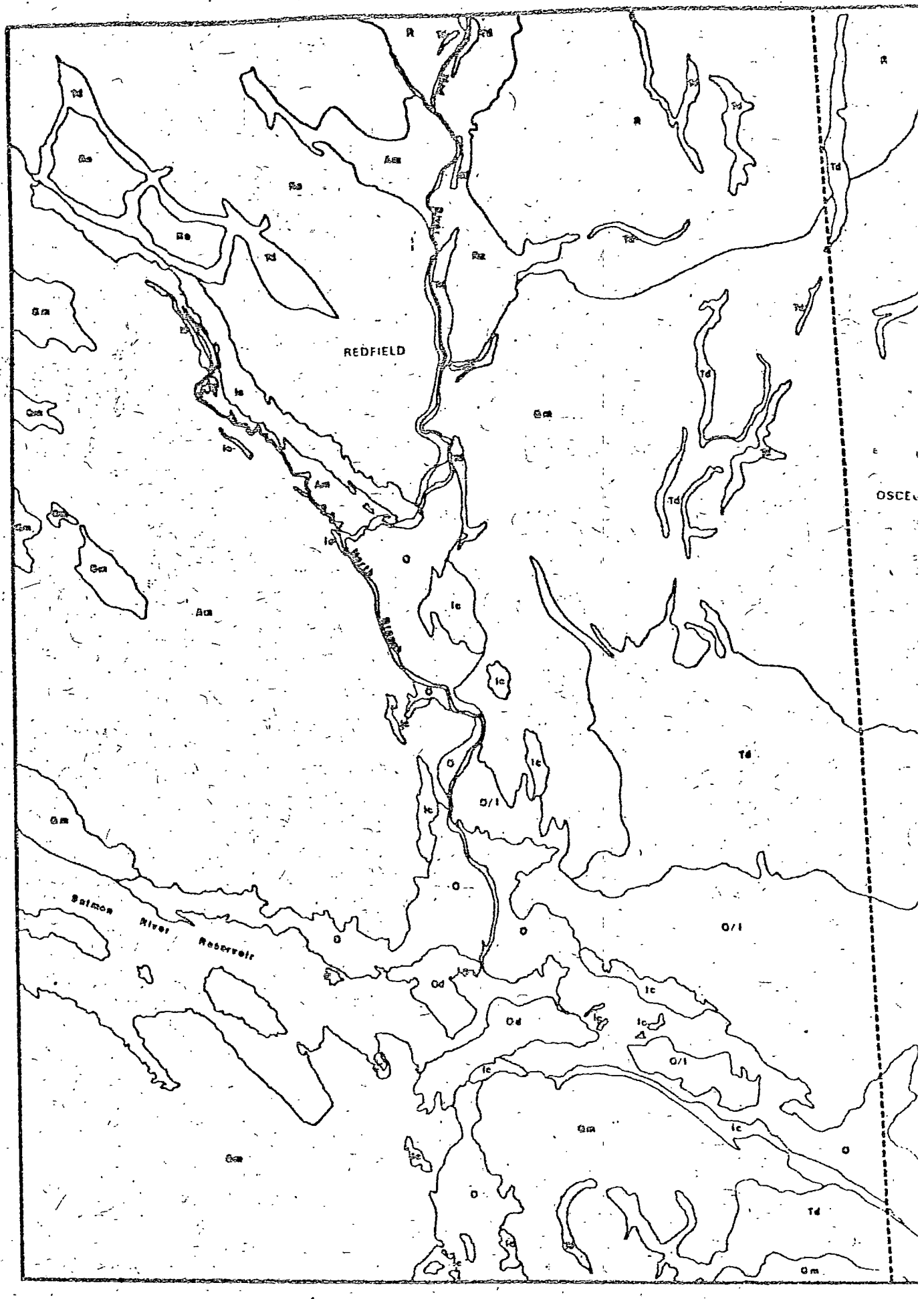
FIG 11



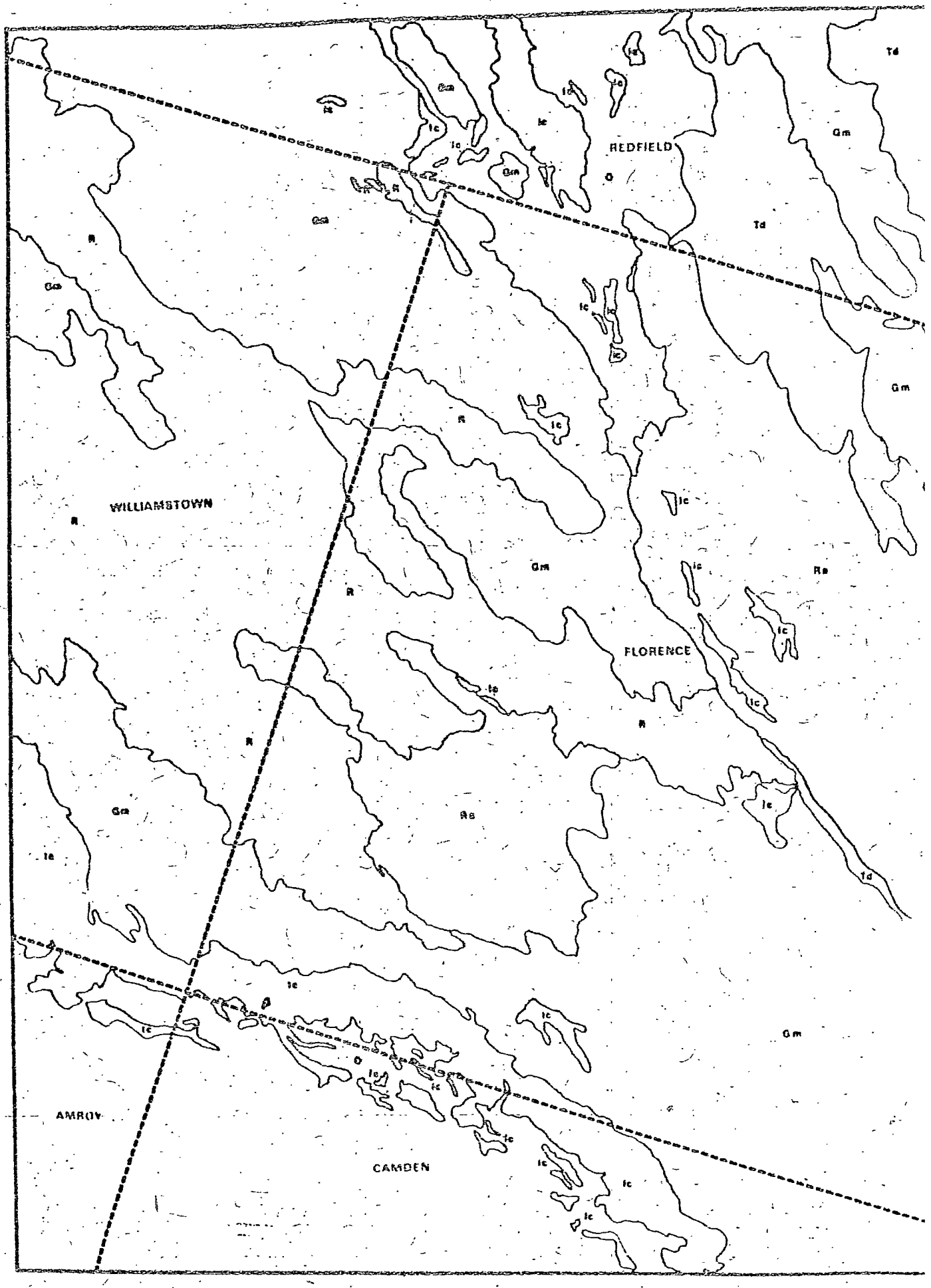


Worth Center

FIG 13

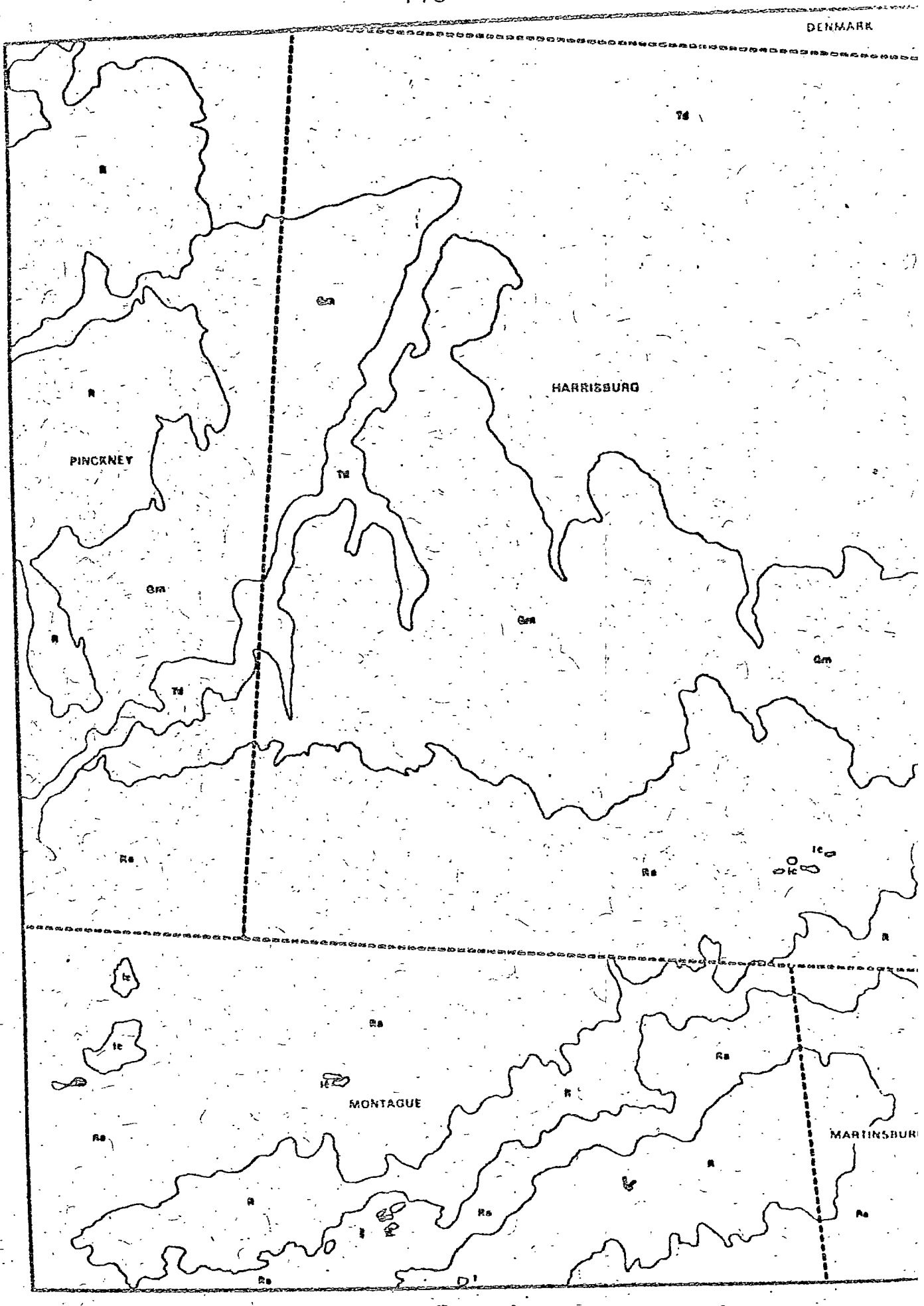


Redfield

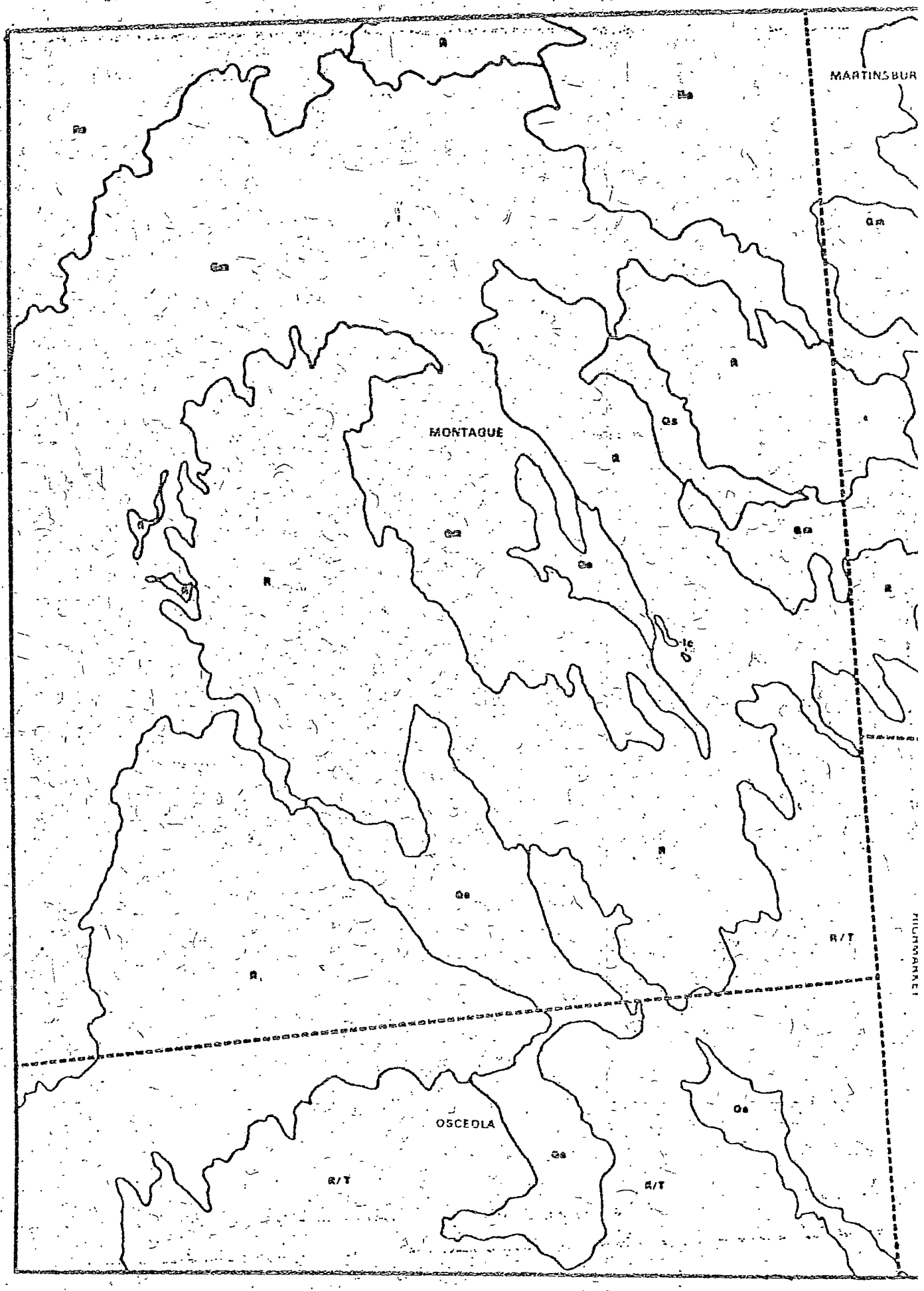

REDFIELD
WILLIAMSTOWN
FLORENCE
AMROY
CAMDEN
Qm
Td
Ic
Qa
Ra
R

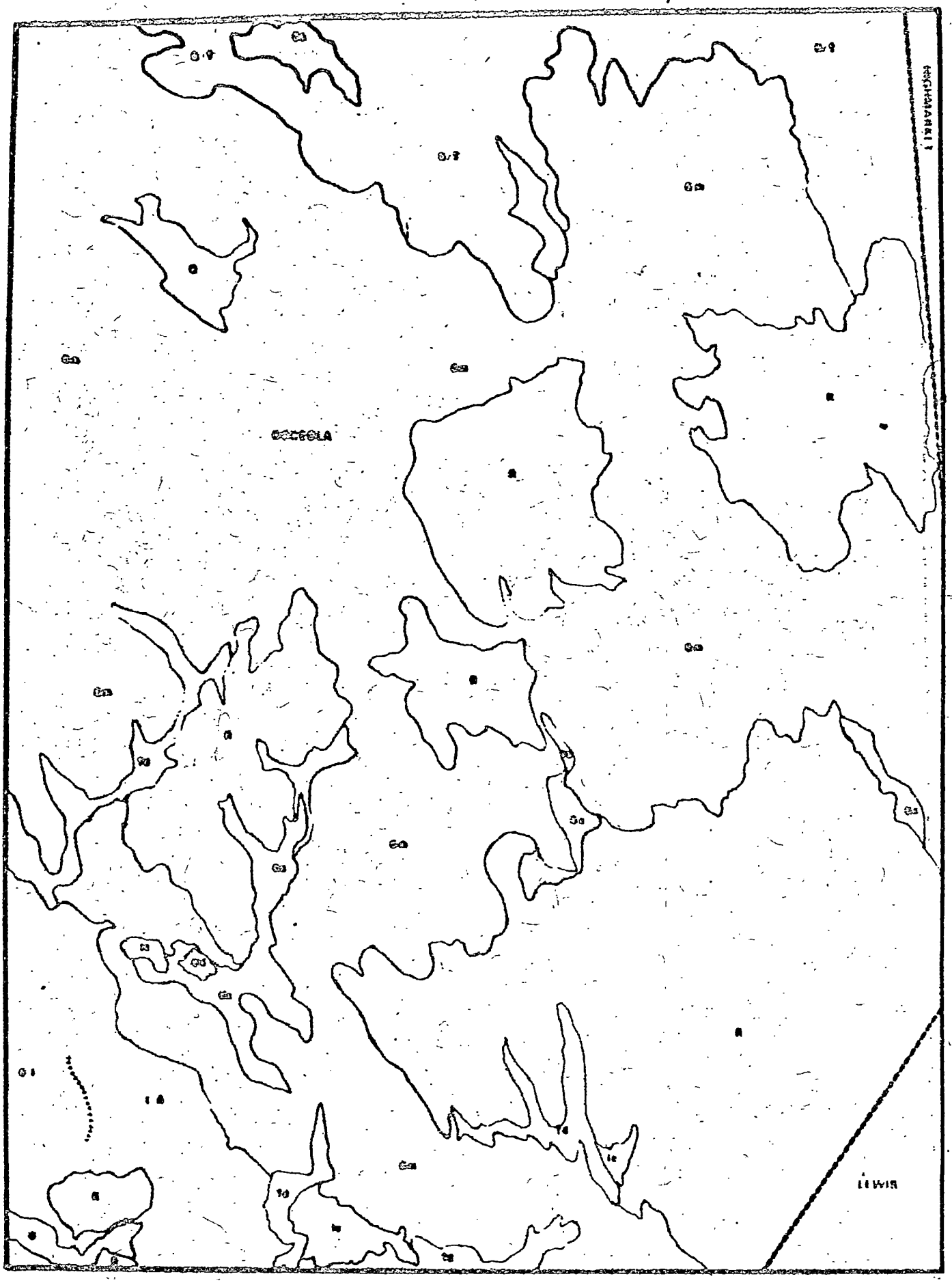
Westdale

FIG 15



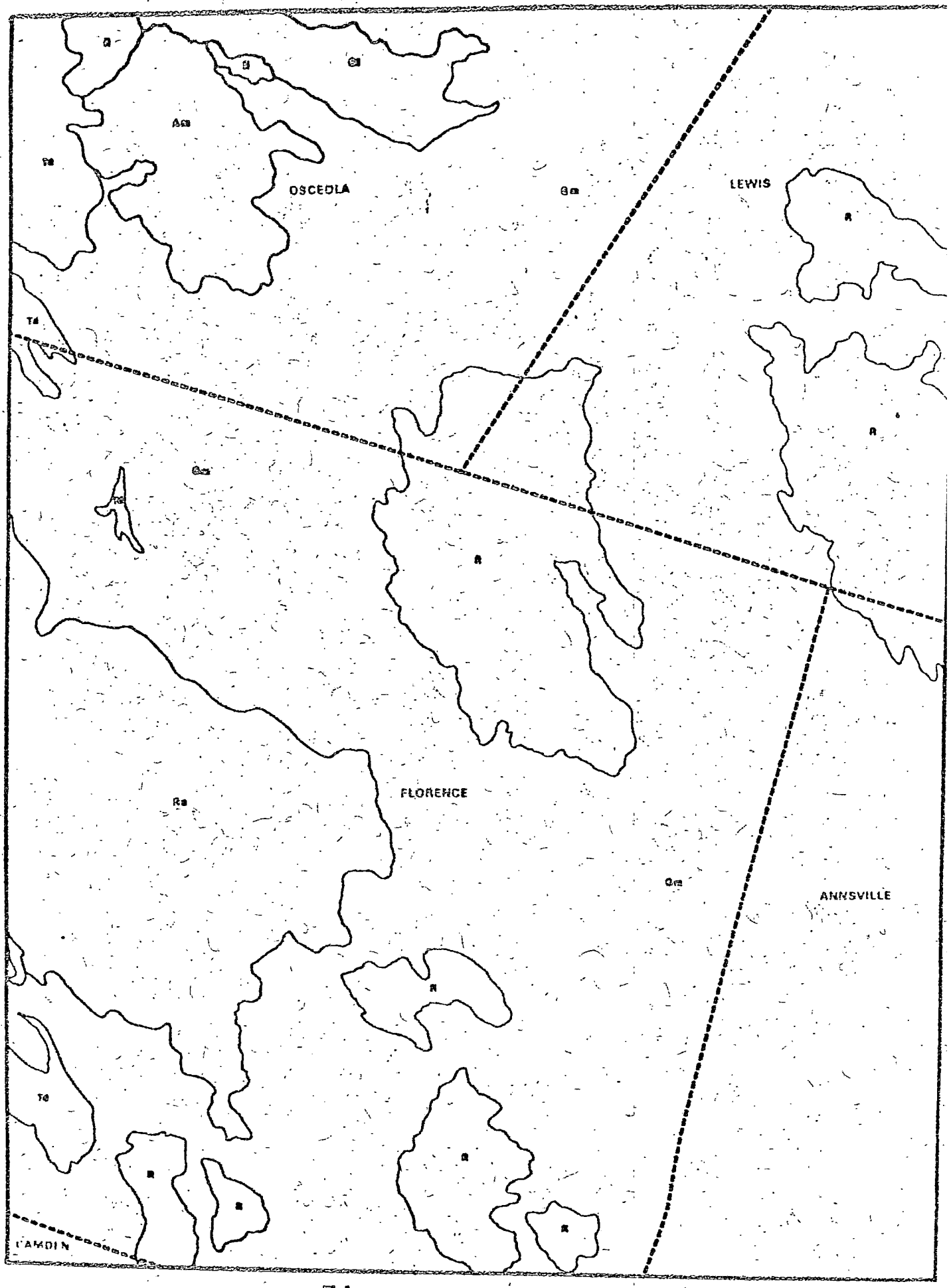
New Boston


MARTINSBUR
MONTAGUE
OSCEOLA
R/T
R/T
R/T
Sears Pond



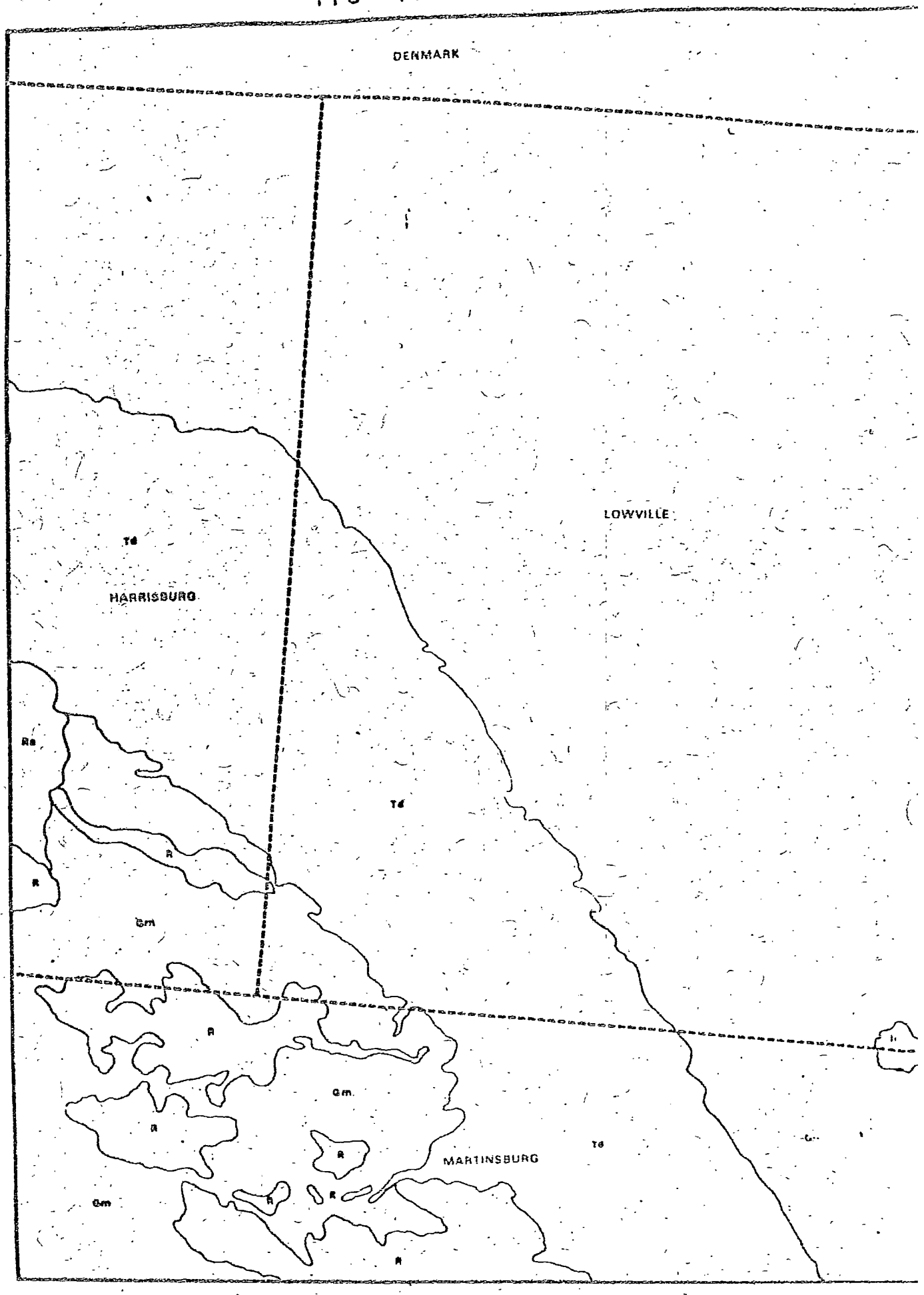
North Osceola

FIG 18



Florence

FIG 19



West Lowville

FIG 20

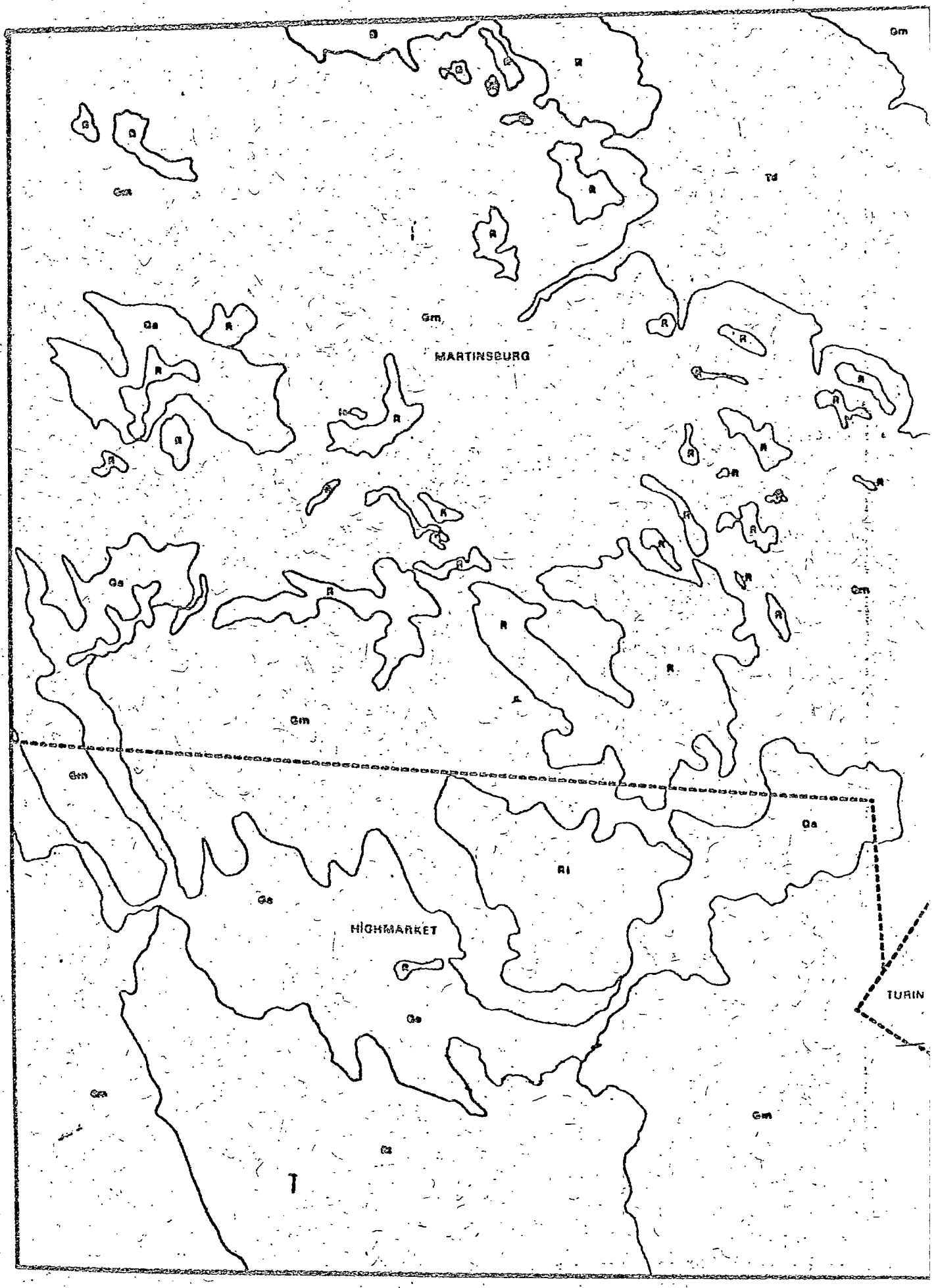
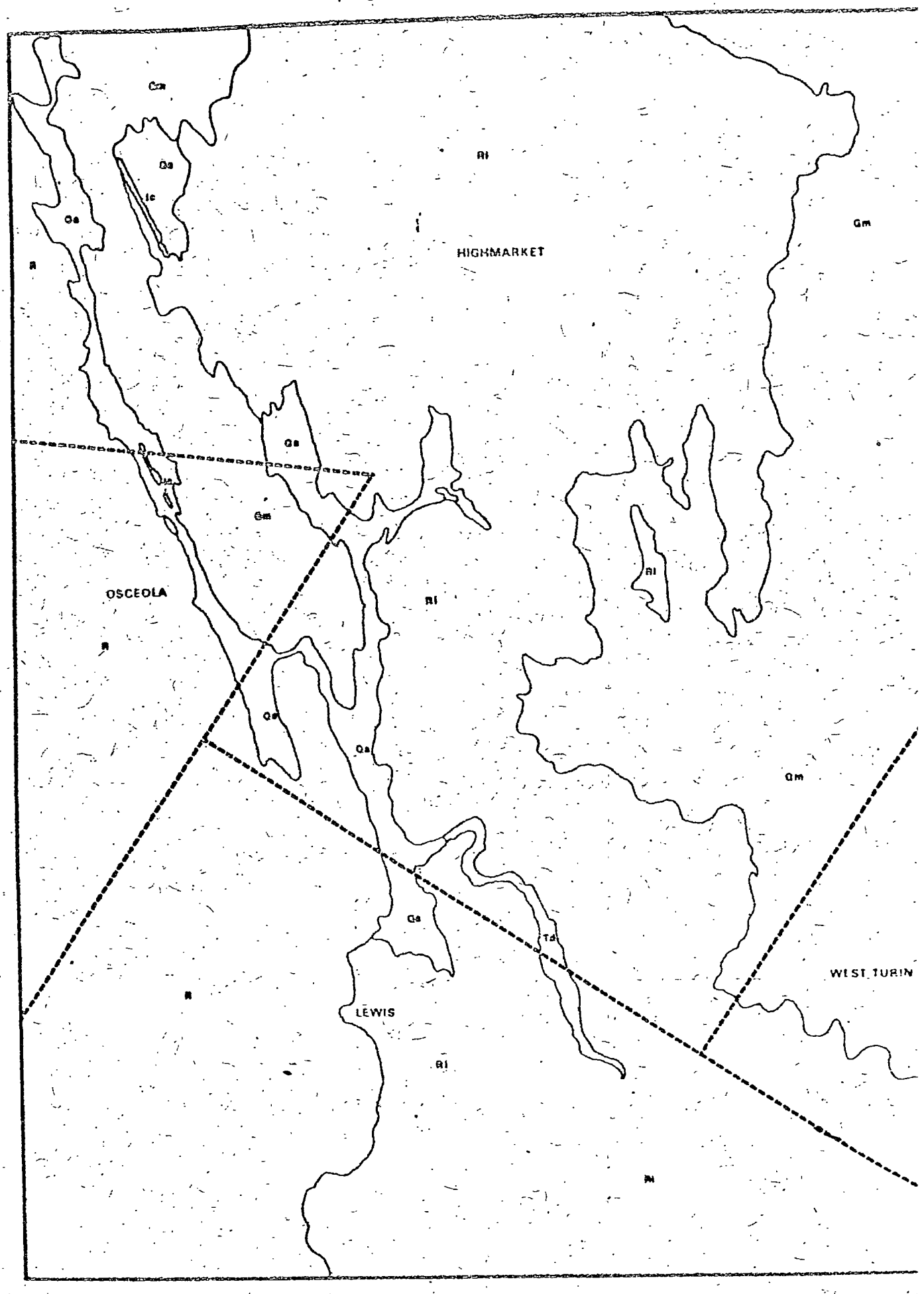
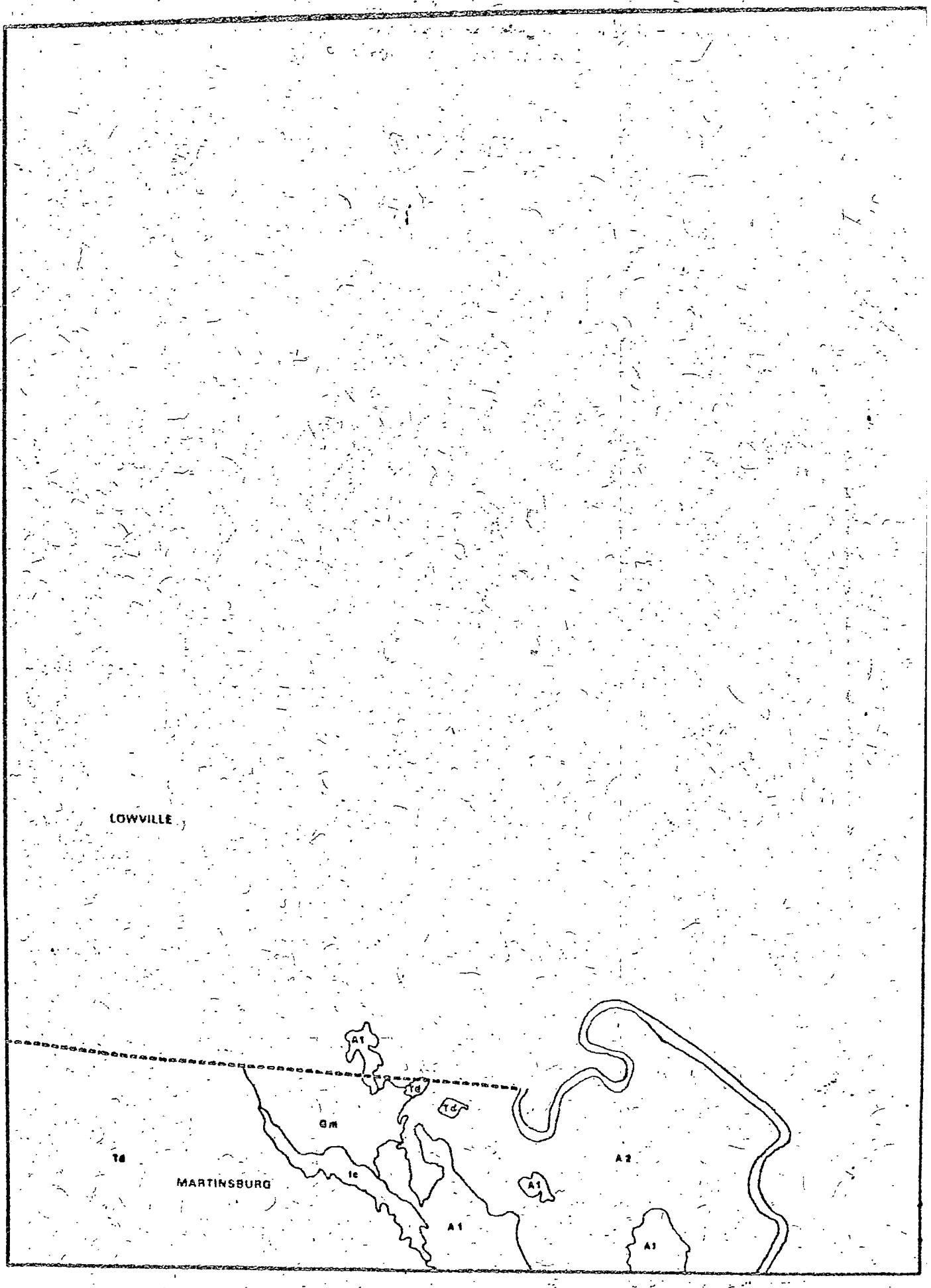

Gm
Td
Gm
MARTINSBURG
Gm
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Ri
Ge
HIGHMARKET
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TURIN
Gm
Gm
Ge

FIG 21

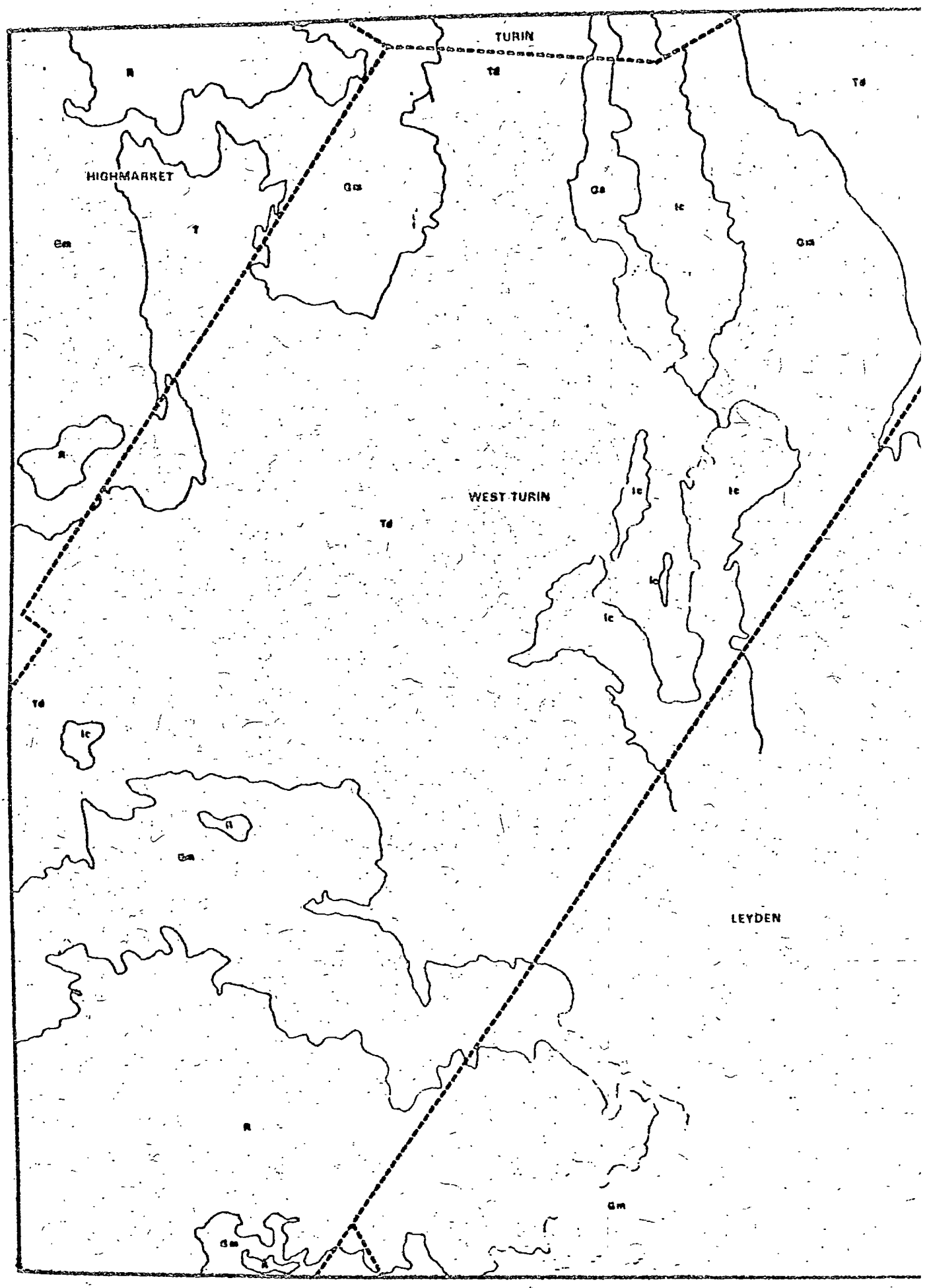


Highmarket

FIG 22



Lowville



Constableville

WETLAND OCCURRENCE AS RELATED TO SURFICIAL GEOLOGY

Wetlands

> Wetlands are those areas of land where water is so abundant that it is the major factor which dictates the nature of plant growth on the site. Relatively dry wetlands may have mature forests as the major vegetation, but the land surface is frequently flooded and the forest floor is covered with ferns and pocked with spring pools where few rooted plants survive.
>
> (J.S. Larson)

Wetlands have been defined in the past on the basis of vegetation (Martin et al, 1953). It is the presence of water, often on the land surface, which dictates the character of that vegetation. The geologic environment is the dominant factor effecting surface and groundwater flow conditions, and consequentially the abundance and distribution of wetlands. Wetland research at the University of Massachusetts has developed a general wetland classification scheme for the northeastern United States. A more detailed classification by Golet (1972) exists for glaciated terrain. These classification schemes define wetland types (i.e. bog vs. wooded swamp) on the basis of the existing plant communities. They do not seek to delineate different wetlands on the basis of their geologic setting. Presently, Holland is developing a wetland classification scheme based upon the environment in Massachusetts. The benefit of such a classification for use in wetland protection and understanding is readily apparent. The use of vegetative populations as a basis for classification will clearly define the boundaries and nature of water abundance over extended periods of time. The complimentary use of a geologic classification will indicate the interrelationships

within the geologic setting conducive to wetland formation. Thus, the need for a dual classification system exists.

New York State Wetland Inventory maps prepared by Cornell University were used to define wetland areas for the purposes of this study. These maps were prepared by aerial photographic interpretation. This study seeks to explain the distribution and abundance of mapped wetland areas in terms of their geologic environment.

The Tug Hill wetlands are found within a series of intergradational glacial environments. These settings are conducive to the formation of wetlands by the manner in which they hinder groundwater and surface water flow.

Five major categories of glacially related wetlands can be identified on the Tug Hill; bedrock, ground moraine, recessional moraine, meltwater channel, and stratified drift related wetlands. The abundance and distribution of each wetland type is related to the dominant glacial feature of the terrain, which dictates slope, surface water and ground water condition.

Slope configuration is a compound function of underlying bedrock and surficial topography. The bedrock offers little dramatic topographic control. Rather, it acts as a platform upon which glacial topography is molded. The southwesterly dip of the Tug Hill cuesta is reflected in the regional slope of the Tug Hill. Local variations in slope are primarily glacial in origin.

Ground water is that component of precipitation which infiltrates the earth's surface. The amount of infiltration possible in any area is directly related to the permeability of

the soil and underlying bedrock. Permeability, the ease with which water can flow through a substance, is a function of grain size, grain shape, and compaction. The relationship of permeability to slope is described by Darcy's Law:

$$V = Px\ (h/l)$$

V - velocity of ground water movement
P - coefficient of permeability
h/l - hydraulic gradient

The water table takes on a subdued mirror image of the surface topography. Thus, the slope of the water table is among other factors, a function of surface slope. In a fine grained, compact material such as lodgment till, interstices are small and unconnected, resulting in low permeability coefficients. Should the hydraulic gradient and the coefficient of permeability be sufficiently low as to restrict ground water flow through a material, the probability of imponding water on the surface is increased.

Water tables are closest to the surface in regions of high rainfall. The Tug Hill averages over 45 inches of water equivalent precipitation annually. The abundance of precipitation is due in part to lake effect, elevation, and the path of Atlantic storm tracks (Behrand et al, 1974). Relatively high water table conditions are present throughout the Tug Hill as a result of the interaction of poor permeabilities and heavy precipitation. Ground water levels were observed at -14 feet on the uplands on the Salmon Valley's south wall in Redfield in July, 1976. Since water table conditions are high even on the divides, a large reduction in slope will induce a corresponding rise in the water table. A level of -3 feet was observed in an unconfined ground moraine region to the north in Worth. Precipitation during the summer

of 1976 was abnormally high, thereby reducing somewhat the normal summer drawdown of the water table. In lowland areas, often found between irregular glacial ridges, the intersection of these lowlands with the water table is common place.

Following is a description of the geologic environments of the Tug Hill Plateau on which wetlands are found.

Wetlands on Bedrock

Areas of exposed or thinly covered bedrock are produced by glacial erosion. Local variations in ice velocity and overburden prevented deposition of thick glacial drift. Thin drift areas are often formed in upland regions where a break in slope occurs. The dominance of glacial erosion over deposition in these areas allows for the creation of local basins carved into bedrock by scouring and abrasive forces. The subsequent lack of substantial deposition prevents these basins from being buried, thus forming a natural site for water accumulation. Areas dominated by bedrock on the Tug Hill occur either in a few wide zones or are restricted to stream channels. Since the stream channels often owe their origin to glacial meltwater channels, wetlands which are in contact with bedrock in these channels are accounted for by a separate classification.

The limited number of regions of exposed bedrock and thin drift cover offer the least permeable substrate to percolating ground water. These areas have thin vadose zones[1], allowing for rapid saturation of the surficial material. Table 1 indicates the average permeability values and hydraulic properties for materials and bedrock of the same nature that are found on the Tug Hill.

[1] soil zone above water table, through which ground water percolates downward

Table 1

Name	Porosity %	Specific Yield %	Permeability gpd/ft^2
Gravel	30-40	15-30	1000-8000
Sand	35-40	10-30	100-3000
Clay, silt	45-55	1-10	0.001-2
Till	20-40	6-16	0.002-24
Sandstone	10-20	5-15	0.1-50
Shale	1-10	.5-5	.00001-0.1
Limestone	1-10	.5-5	40, highly variable
Igneous Rocks	0-40	0-30	0-35, highly variable
Metamorphic Rocks	0-40	0-30	0-35, highly variable

(Johnson, 1966)

Wetlands on Till

Till-controlled wetlands can be subdivided into two categories, ground moraine controlled and ablation moraine controlled. Ground moraine on the Tug Hill is predominantly lodgment till with a thin cover of ablation till. The ground moraine is expressed as drumlinized ridges and inter-drumlin lowlands. The inter-drumlin lows form basins between the adjacent drumlins. The impermeable nature of the lodgment till (table 1), in conjunction with the surface runoff from the flanks of the adjacent drumlins creates high water table conditions.

Although ablation moraine is genetically more related to recessional moraine than ground moraine, wetland basins found within zones of ablation moraine are not so related. The dominant topographic expression in ablation moraine zones is the underlying drumlinized ground moraine. Consequently, the wetland basins formed in ablation moraine are related to the ground moraine. On ablation moraine the stream drainage flow between drumlins is often blocked by thick accumulations of ablation drift. The ablation drift is predominantly ablation till with sporadic kame deposits. These deposits act as a barrier to surface water drainage, which compounds the already poor drainage in the underlying ground moraine. Wetlands of this nature are observed in Boylston and Redfield.

Wetlands in Meltwater Channels

Two types of meltwater channels are formed by streams flowing off the glacier. Pro-glacial streams flow away from the ice front. The southeasterly drainage of many small streams and wetlands is due to these pro-glacial drainage courses. However, these drainage lines were controlled by the drumlin topography. In areas not characterized by drumlins, pro-glacial channels would constitute a major class of wetland basin. Since the drumlin topography controlled the flow direction on the Tug Hill, wetlands of this nature are classified under ground moraine control.

Marginal meltwaters also form streams parallel to the glacier terminus. High velocities and discharge produced deeply incised bedrock channels. These channels are observed in the western segment, often with a north-south orientation. Present flow conditions do not require the depth or width that these channels attained during the deglaciation of the Tug Hill. As a result, wetlands form in bottom of the channels due to insufficient drainage across the channel floors. The wetland basins are supplied by the flow of ground water migrating through the channel walls.

Wetlands in Recessional Moraine Zones

Recessional moraine areas are characterized by the most dense cover of glacial drift on the Tug Hill. Recessional moraine ridges are formed parallel to the ice margin, and are primarily composed of lodgment till. Kame and ablation moraine deposits are found interspersed within recessional moraine belts. The surface of the recessional moraine ridges is often covered by variable thichnesses of ablation drift. The deposition of the ablation drift created small kettle depressions on the surface of the ridges. The kettle depressions are the sites of small wetlands within recessional moraine zones. Between two recessional moraine ridges exists a topographic low region composed of lodgment till. These inter-ridge lowland areas are the sites of numerous wetlands in recessional moraine regions.

Recessional moraines are formed with no regard to the underlying topography. That is, drumlins or other positive relief features, can be partially buried or completely obliterated by the formation of the recessional moraines. As a result a series of topographic elements can be superimposed on one another. The drumlins are obscured by recessional moraines, which in turn are partially concealed beneath ablation drift. The product of this superimposing of glacial deposits is the blockage of drainage lines. As a result, inter-recessional moraine lowlands are rarely continuous. Wetlands within recessional moraine zones increase with distance from major drainage courses, suggesting the increased difficulty of continuous surface flow. The majority of wetlands within recessional moraine zones are confined to the inter-ridge lowlands. The small wetlands that form in the kettle

depressions on the ridge surfaces are almost the exclusive product of low permeability conditions. The larger inter-ridge basins receive large quantities of surface runoff from the adjacint recessional moraines, in addition to the water imponded due to the low permeability on the flat bottom basins.

Wetlands on Stratified Drift

Stratified drift, be it fine sands or coarse gravels, is a more permeable material than till (table 1). Wetlands formed in surficial materials exhibiting high permeabilities, require other factors to take precedence over the porous nature of the surficial cover during their formation. Generally, wetlands related to stratified drift are restricted to larger valleys on the Tug Hill, but do occur in ablation and recessional moraine zones associated with kames and kettles.

Stratified drift related wetlands can be subdivided into ice contact or non ice contact. Ice contact related wetlands formed as a result of the irregular surfaces that are produced during wastage of stagnant ice. Ground water is able to migrate through the well sorted sand and gravels. Wetlands occur in ice contact deposits as a product of the intersection of kettle depressions by the water table. Non ice-contact wetlands can be the product of a similar water table relationship or due to confinement within a valley. In a confined situation, the water table level is maintained at a higher level than the permeability conditions would normally allow. Lakes produced by natural or man made dams effectively raise the water table. The Salmon Valley offers numerous examples of wetlands formed on outwash materials which owe their origin to the artificially induced high water table conditions.

In some of the marginal meltwater channels wetlands have formed on ice-contact deposits within those channels. These wetlands owe their distribution to the meltwater channel configuration, not the stratified drift. Wetlands of this nature are classified as meltwater related.

Wetland Distribution

The abundance of wetlands on the Tug Hill can be attributed to the relatively short time interval since its deglaciation. Poor drainage is characteristic of recently deglaciated landscapes (Thornburry, 1969). Stewart (1958) attempted to apply this principal in the Sandy Creek area. He noted that a better developed drainage system existed in the glacial drift to the south of Sandy Creek, suggesting that the drift to the south was older (Cary age) than the drift to the north (Port Huron age). This hypothesis has been contested as being inconclusive (Street, 1966), (p. , this volume). The drainage throughout the Tug Hill is poor due to the nature of the glacial drift and landforms.

Data obtained from the IJNR wetland inventory were compiled in conjunction with the surficial mapping. The classification of Tug Hill wetlands by their geologic setting is listed in Table 2. Over 4,000 wetland basins have been identified and classified. The percentages listed for wetland occurence, pertain to wetland abundance, not their aerial size. The abundance percentages would hold generally the same with regard to size, with the exception of till controlled wetlands. Till controlled wetlands would constitute a larger proportion of the size fraction due to their control by underlying drumlins. Drumlins are the largest glacial landforms found on the Tug Hill. Consequently, the largest wetland basins are formed between these features.

Wetlands formed in recessional moraine zones, although

more numerous due to the spatial density of the moraine ridges, are small in size due to the discontinous nature of recessional moraine features.

The wetland distribution and occurence for the nine towns is summarized in Tables 3-11 and figures 25-33. The generalized wetland maps (figs. 25-33), compared to the surficial maps (figs. 8-24), demonstrate the interrelationship between wetland distribution and abundance, and the surficial geology.

Table 2
Tug Hill Wetland Distribution

Wetland Type	Observed	%Observed
Wetlands in marginal melt-water	86	2.1%
Wetlands on stratified drift		
Ice-contact	108	2.6%
Non ice-contact	45	1.1%
Subtotal stratified drift wetlands	153	3.7%
Wetlands controlled by till		
Ground moraine	1,457	35.3%
Ablation moraine	205	4.9%
Till wetlands subtotals	1,662	40.2%
Wetlands related to recessional moraines	2,165	52.3%
Wetlands controlled by bedrock	65	1.6%
Total	4,127	99.9%

Table 3

Highmarket-West Turin

Wetland Type	Sears Pond	Page	North Osceola	Highmarket	West Lowville	Constableville	Total Observed	% Observed
Wetlands in marginal meltwater	-	-	-	-	-	5	5	.5%
Wetlands on stratified drift								
Ice-contact	-	-	-	-	-	18	18	1.9%
Non ice-contact	-	-	-	-	-	8(a)	8	.9%
Subtotal stratified drift wetlands	-	-	-	-	-	26	26	2.8%
Wetlands controlled by till								
Ground moraine	-	114	-	137	-	117	368	40.6%
Ablation moraine	-	-	-	-	-	-	-	-
Till wetlands subtotals	-	114	-	137	-	117	368	40.6%
Wetlands related to recessional moraines	28	108	4	240	10	99	483	53.3%
Wetlands controlled by bedrock	-	-	-	-	-	24	24	2.6%
Total*	28	222	4	377	10	271	906	99.9%

* data from Glenfield not available



Fig. 25 Generalized Wetland Map

Highmarket-West Turin, New York

Martinsburg

Table 4

Wetland type	New Boston	Sears Pond	Page	West Lowville	Total Observed	% observed
Wetlands in marginal melt-water	-	-	15	9	24	5.8%
Wetlands on stratified drift						
Ice-contact	-	-	1	-	1	-
Non ice-contact	-	-	-	-	-	-
Subtotal stratified drift wetlands	-	-	1	-	1	.2%
Wetlands controlled by till						
Ground moraine	-	15	218	28	261	62.9%
Ablation moraine	-	-	-	-	-	-
Till wetlands subtotals	-	-	218	28	261	62.9%
Wetlands related to recessional moraines	32	27	31	23	123	29.6%
Wetlands controlled by bedrock	-	-	4	2	6	1.4%
Total	32	42	488	90	415*	99.9%

* data from Lowville and Glenfield not available

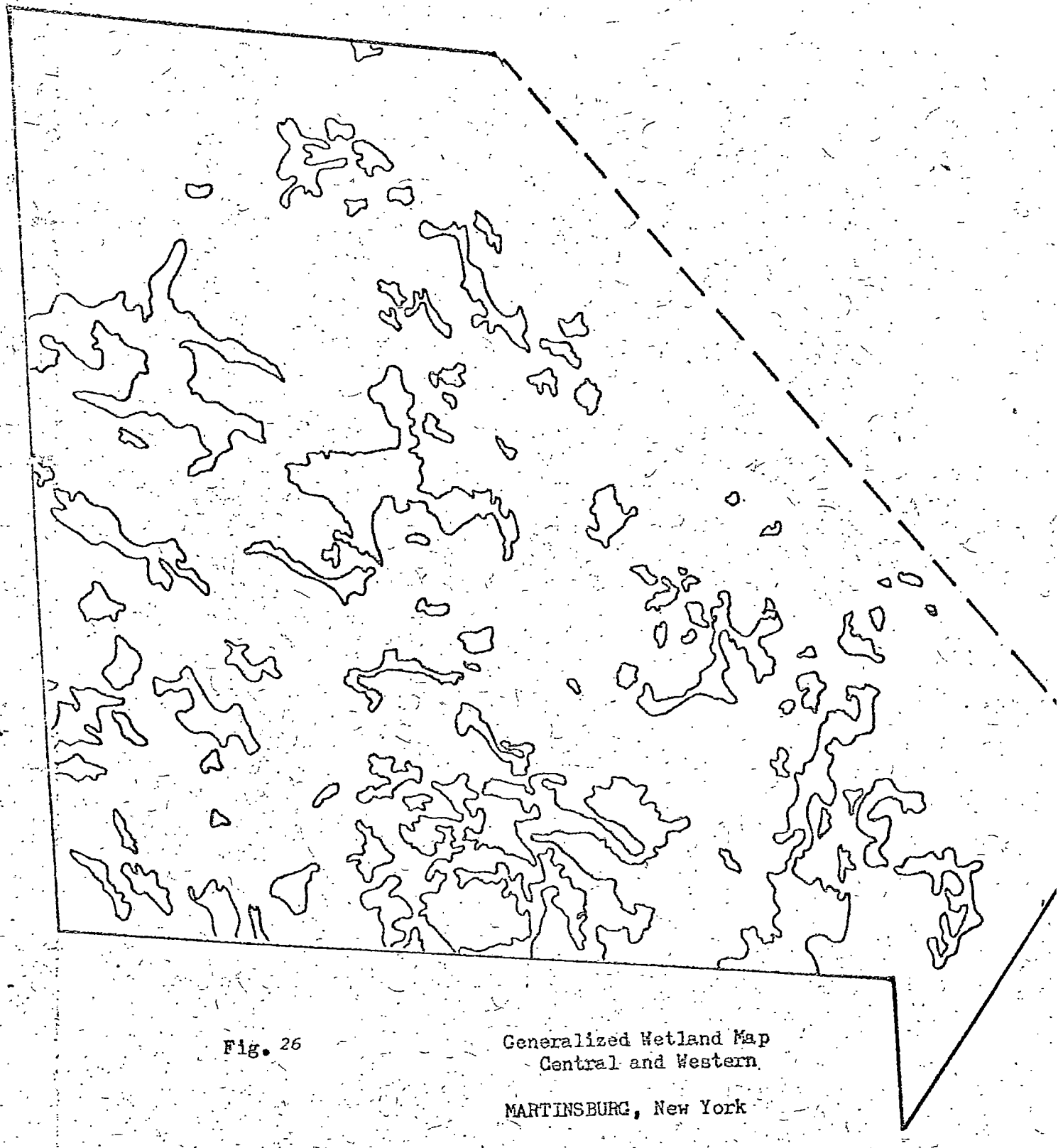


Fig. 26 Generalized Wetland Map
Central and Western

MARTINSBURG, New York

Table 5

Florence

Wetland Type	Florence	Total
Wetlands in marginal melt-water	-	-
Wetlands on d'tratified drift		
Ice-contact	-	-
Non ice-contact	-	-
Subtotal stratified drift wetlands	-	-
Wetlands controlled by till		
Ground moraine	47	47
Ablation moraine	-	-
Till wetlands subtotals	47	47
Wetlands related to recessional moraines	27	27
Wetlands controlled by bedrock	-	-
Total	74*	74

*data from Westdale not available

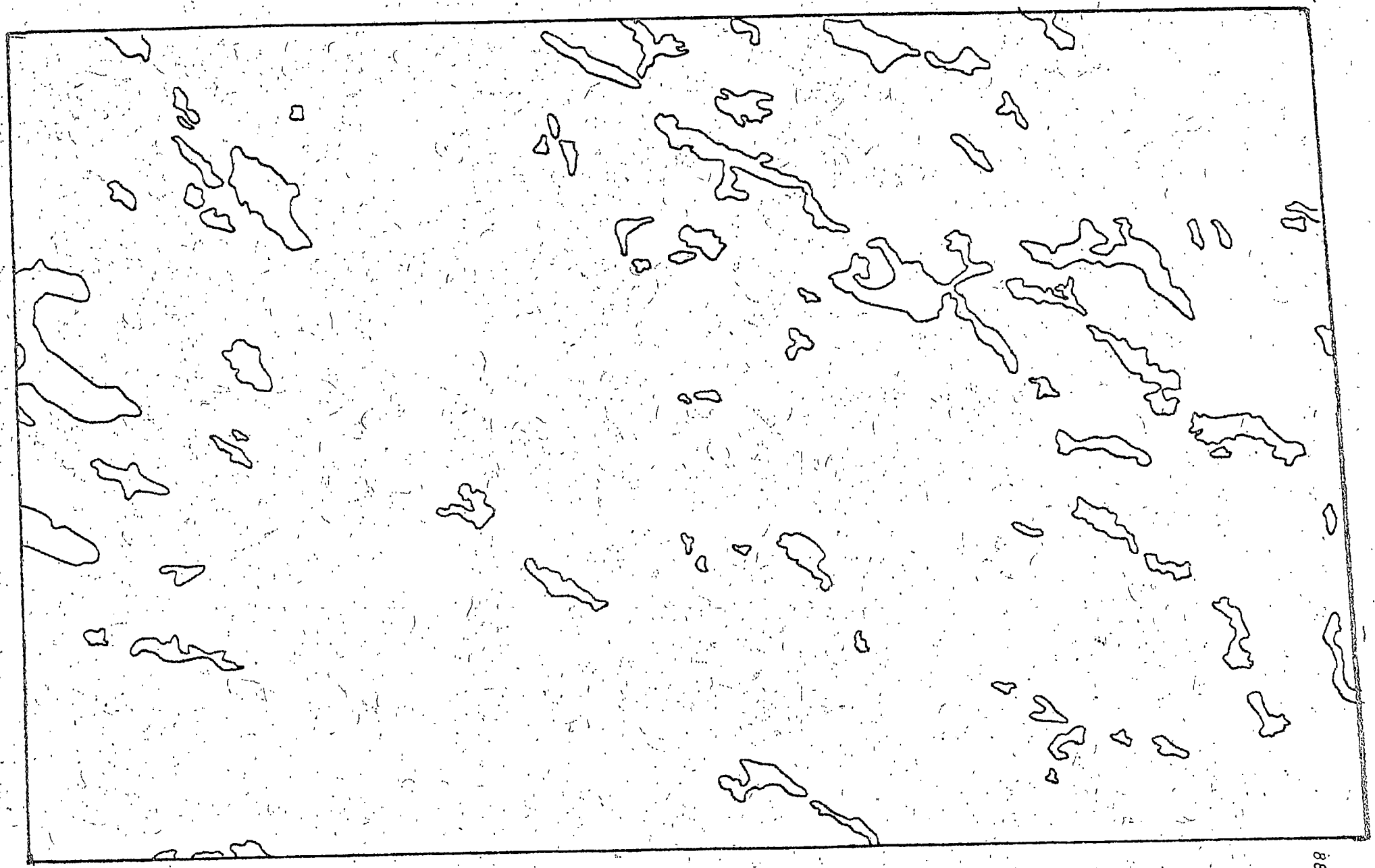


Fig. 27 Generalized Wetland Map

Table 6

Pickney

Wetland type	Barnes Corner	New Boston	Total observed	% observed
Wetlands in marginal meltwater	3	1	4	1.3%
Wetlands on stratified drift Ice-contact Non ice-contact	3 -	- -	3 -	.9% -
Subtotal stratified drift wetlands	3	-	3	.9%
Wetlands controlled by till Ground moraine Ablation moraine	115 -	44 -	149 -	47.3% -
Till wetlands subtotals	115	44	149	47.3%
Wetlands related to recessional moraines	99	49	148	46.9%
Wetlands controlled by bedrock	11	-	11	3.5%
Total	231	94	31.5	99.9%

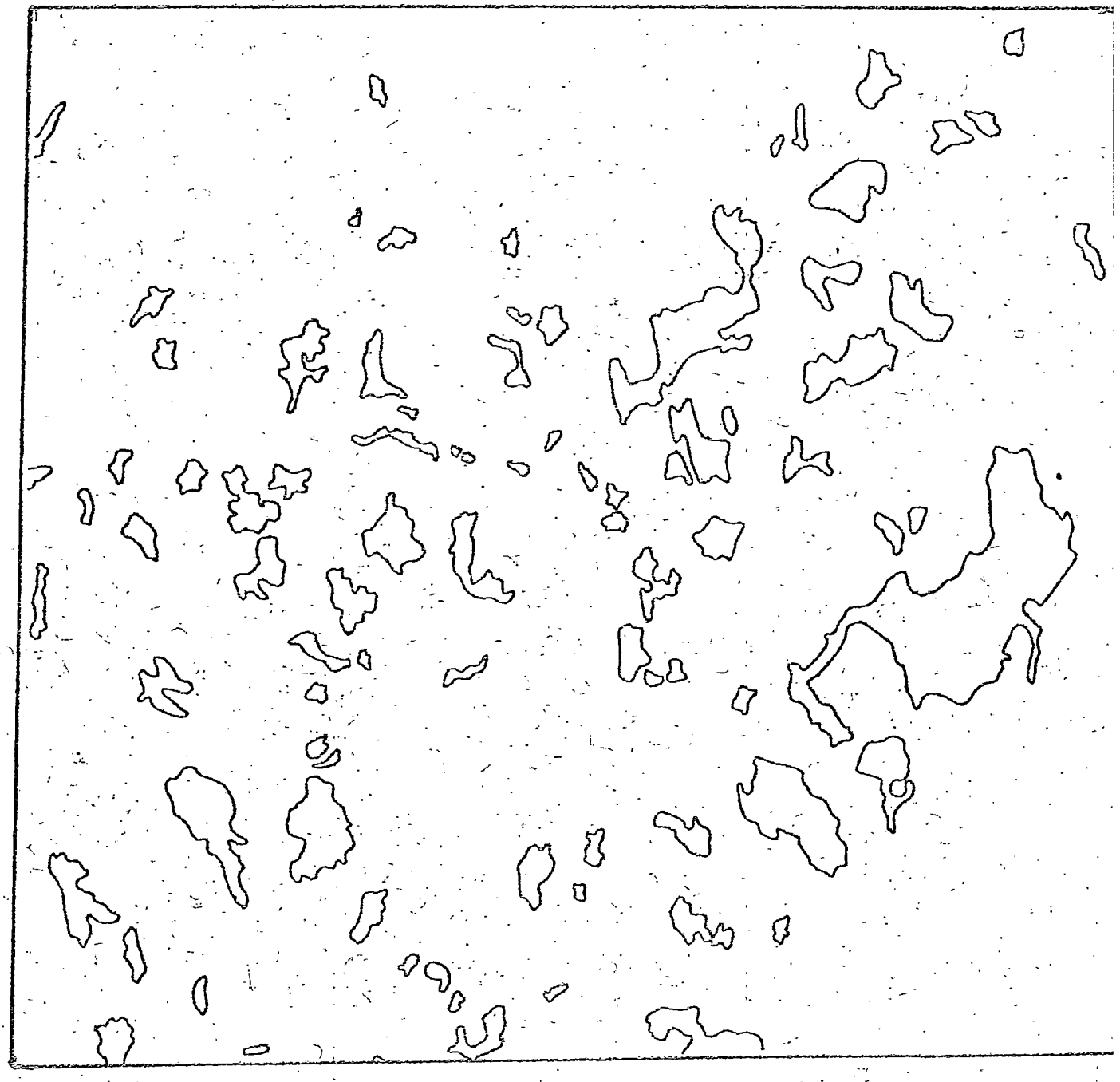


Fig. 28 Generalized Wetland Map

Pinckney, New York

Table 7

Redfield

Wetland type	Redfield	Barnes Corner	Worth Center	Total Observed	% Observed
Wetlands in marginal meltwater	76	-	9	16	4.9%
Wetlands on stratified drift					
Ice-contact	28	-	5	33	10.1%
Non ice-contact	27	-	-	27	8.3%
Subtotal stratified drift wetlands	55	-	5	60	18.4%
Wetlands controlled by till					
Ground moraine	41	-	-	41	12.6%
Ablation moraine	18	5	24	47	14.4%
Till wetlands subtotals	59	5	24	88	27%
Wetlands related to recessional moraines	5	-	148	153	46.9%
Wetlands controlled by bedrock	9	-	-	9	2.8%
Total*	259	10	215	326	100%

* data from Westdale and Orwell not available

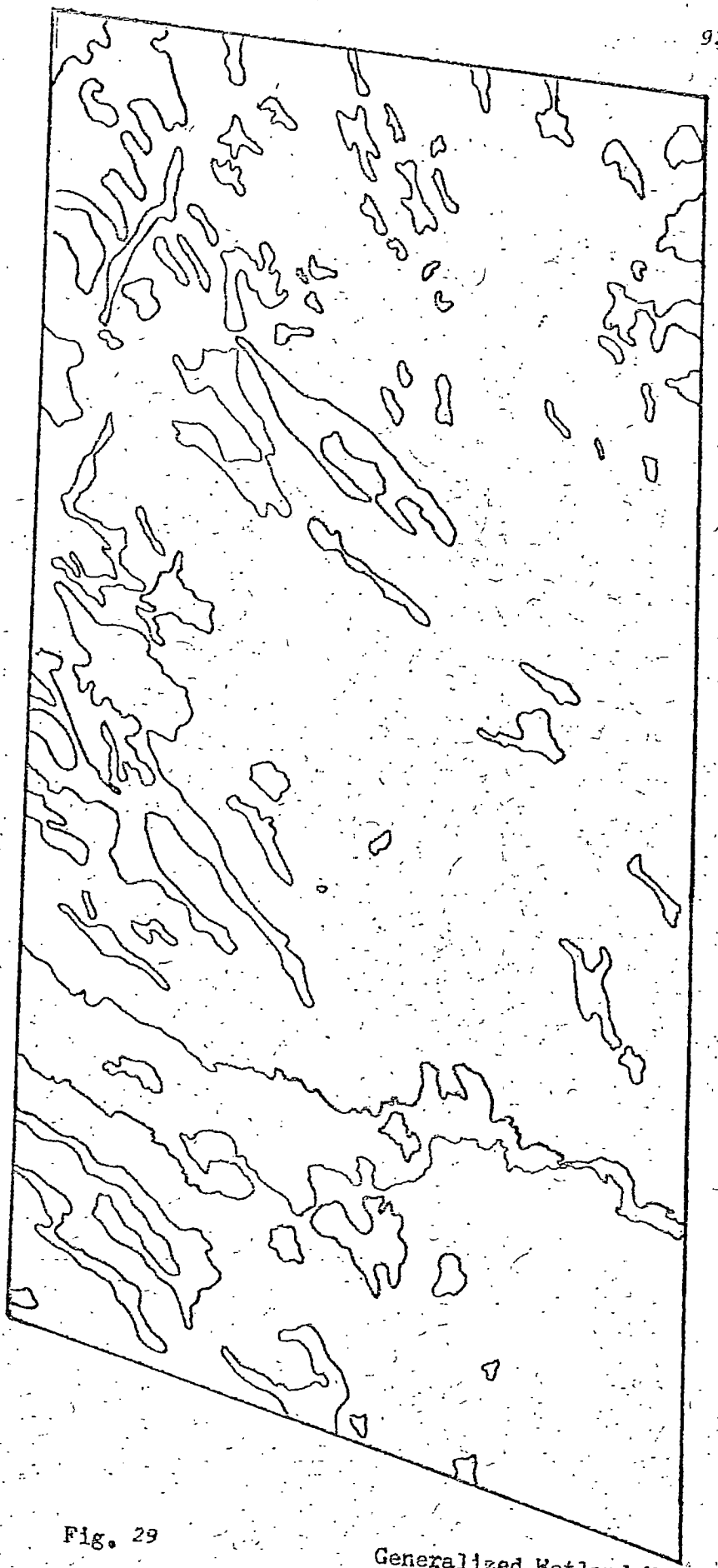


Fig. 29

Generalized Wetland Map

REDFIELD, New York

Table 8

Boylston

Wetland type	Boylston Center	Sandy Creek	% Observed
Wetlands in marginal meltwater	11	14	18.8%
Wetlands on stratified drift			
Ice-contact	1	-	.70%
Non ice-contact	-	-	-
Subtotal stratified drift wetlands	1	-	.70%
Wetlands controlled by till			
Ground moraine	15	-	11.3%
Ablation moraine	92	-	69.2%
Till wetlands subtotal	107	-	81%
Wetlands related to recessional moraines	-	-	-
Wetlands controlled by bedrock	-	-	-
Total*	133	-	100%

* data from Orwell not available

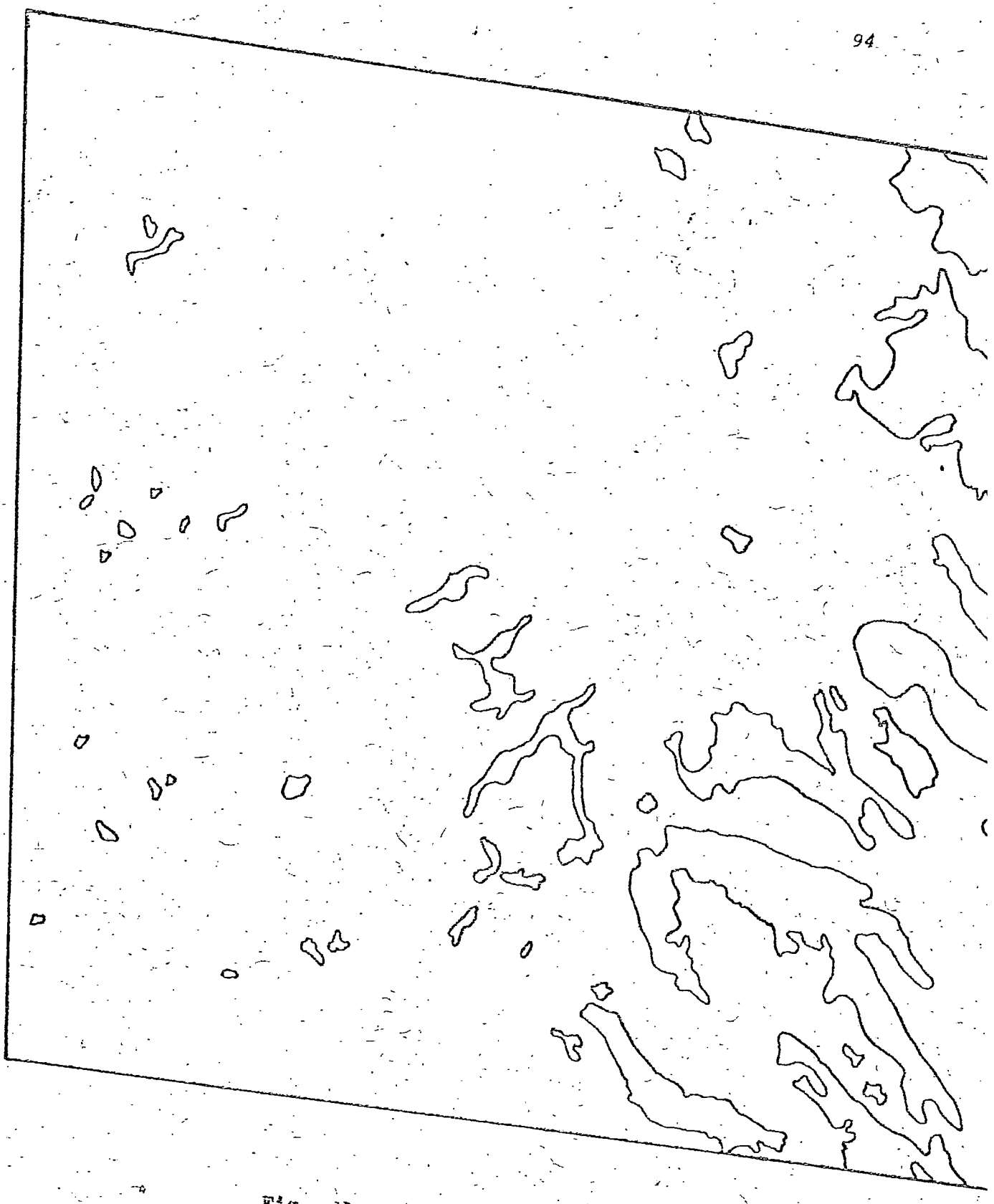


Fig. 30 Generalized Wetland Map

Boylston, New York

Table 9

Montague

Wetland type	Barnes Corner	Worth Center	Sears Pond	New Boston	Total Observed	% Observed
Wetlands in marginal meltwater	-	-	-	-	-	-
Wetlands on stratified drift Ice-contact Non ice-contact	2 -	- -	- -	3 -	5 -	.6% -
Subtotal stratified drift wetlands	2	-	-	3	5	.6%
Wetlands controlled by till Ground moraine Ablation moraine	3 4	- 14	177 -	- -	180 18	24% 2.4%
Till wetlands subtotals	7	14	177	-	198	26.8%
Wetlands related to recessional moraines	53	26	327	140	546	72.9%
Wetlands controlled by bedrock	-	-	-	-	-	-
Total	62	40	504	143	749	99.9%

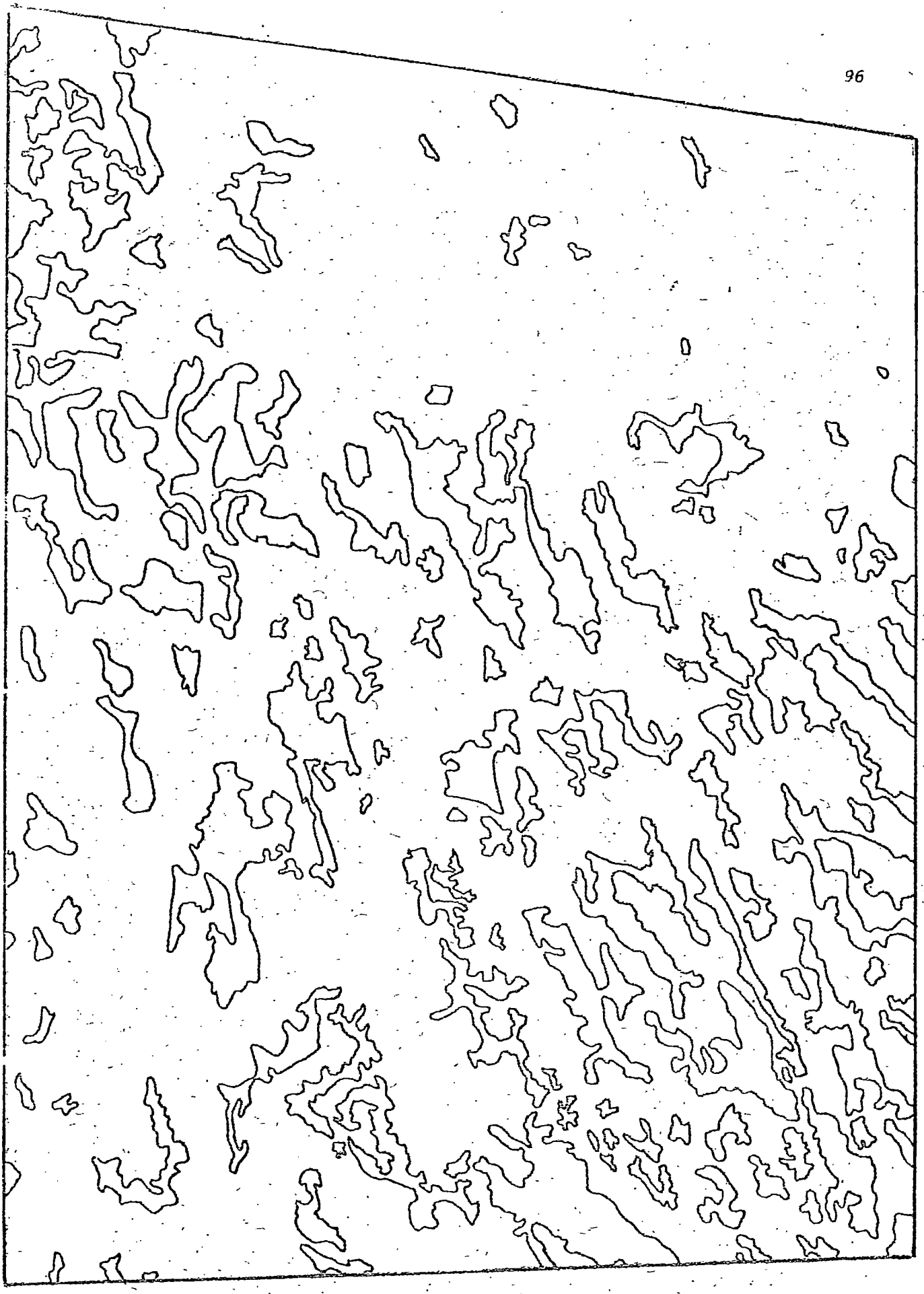


Fig. 31 Generalized Wetland Map

MONTAGUE, New York

Table 10

Osceola

Wetland type	North Osceola	Redfield	Worth Center	Highmarket	Sears Pond	Florence	Total Observed	%Observed
Wetlands in marginal meltwater	5	5	-	-	-	2	12	1.4%
Wetlands on stratified drift								
Ice-contact	14	5	-	1	-	-	20	2.4%
Non ice-contact	4	2	-	-	-	4	10	1.2%
Subtotal stratified drift wetlands	18	7	-	1	-	4	30	3.6%
Wetlands controlled by till								
Ground moraine	227	11	-	18	30	52	338	40.7%
Ablation moraine	-	-	-	-	-	15	15	1.8%
Till wetlands subtotals	227	11	-	18	30	67	353	42.5%
Wetlands related to recessional moraines	236	4	14	53	118	-	424	51.1%
Wetlands controlled by bedrock	-	5	-	-	-	10	15	1.8%
Total*	731	50	14	91	178	154	829	100%

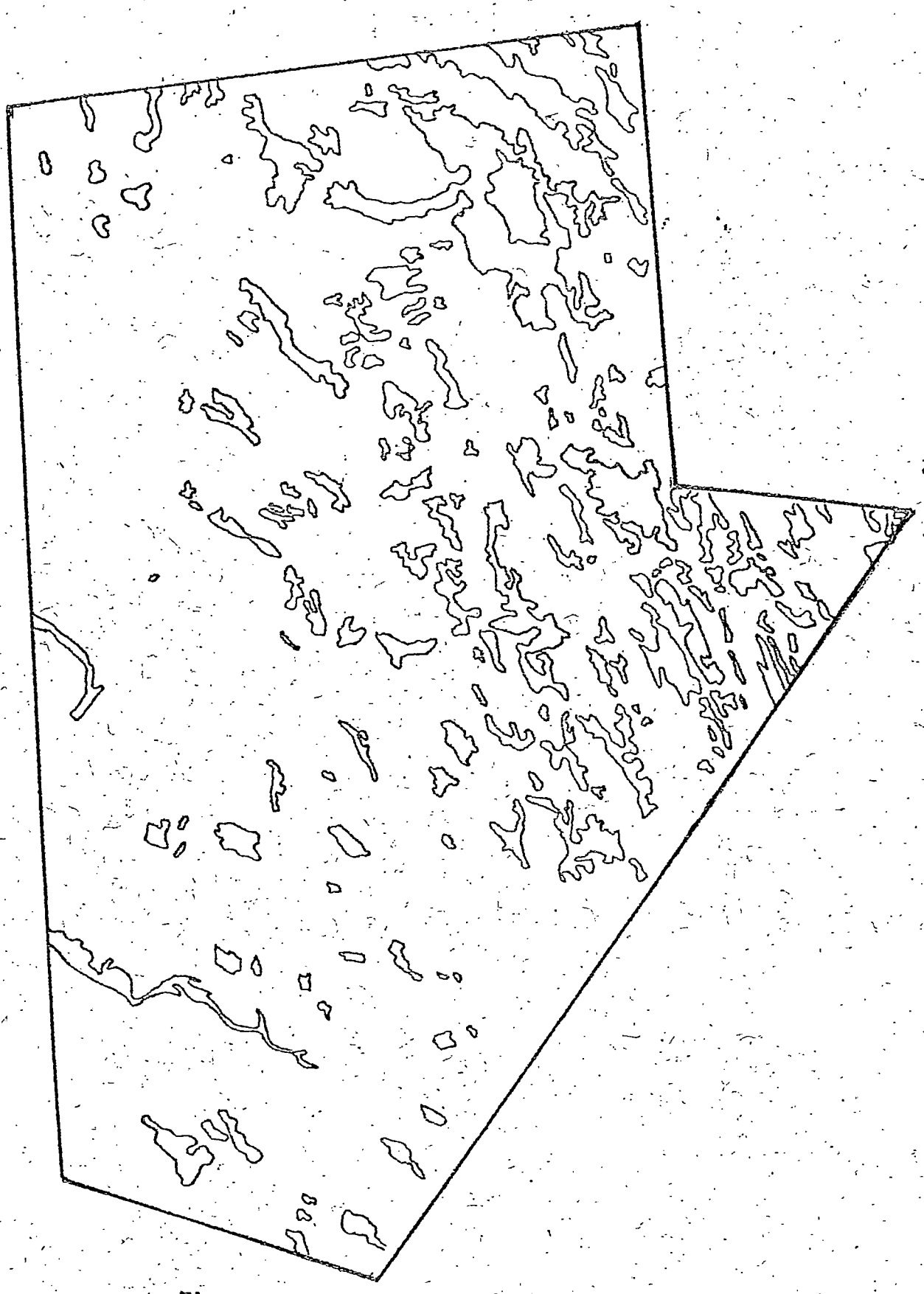


Fig. 32 Generalized Wetland Map
OSCEOLA, New York

Table 11

Worth

Wetland Type	Worth Center	Boylston Center	Barnes Corner	Total Observed	%Observed
Wetlands in marginal meltwater	-	-	-	-	-
Wetlands on stratified drift					
Ice-contact	19	-	8	27	6.4%
Non ice-contact	-	-	-	-	-
Subtotal stratified drift wetlands	19	-	8	27	6.4%
Wetlands controlled by till					
Ground moraine	-	18	40	58	13.7%
Ablation moraine	45	26	9	80	18.9%
Till wetlands subtotals	45	44	49	138	32.6%
Wetlands related to recessional moraines	142	21	94	257	60.9%
Wetlands controlled by bedrock	-	-	-	-	-
Total *	206	65	153	422	99.9%

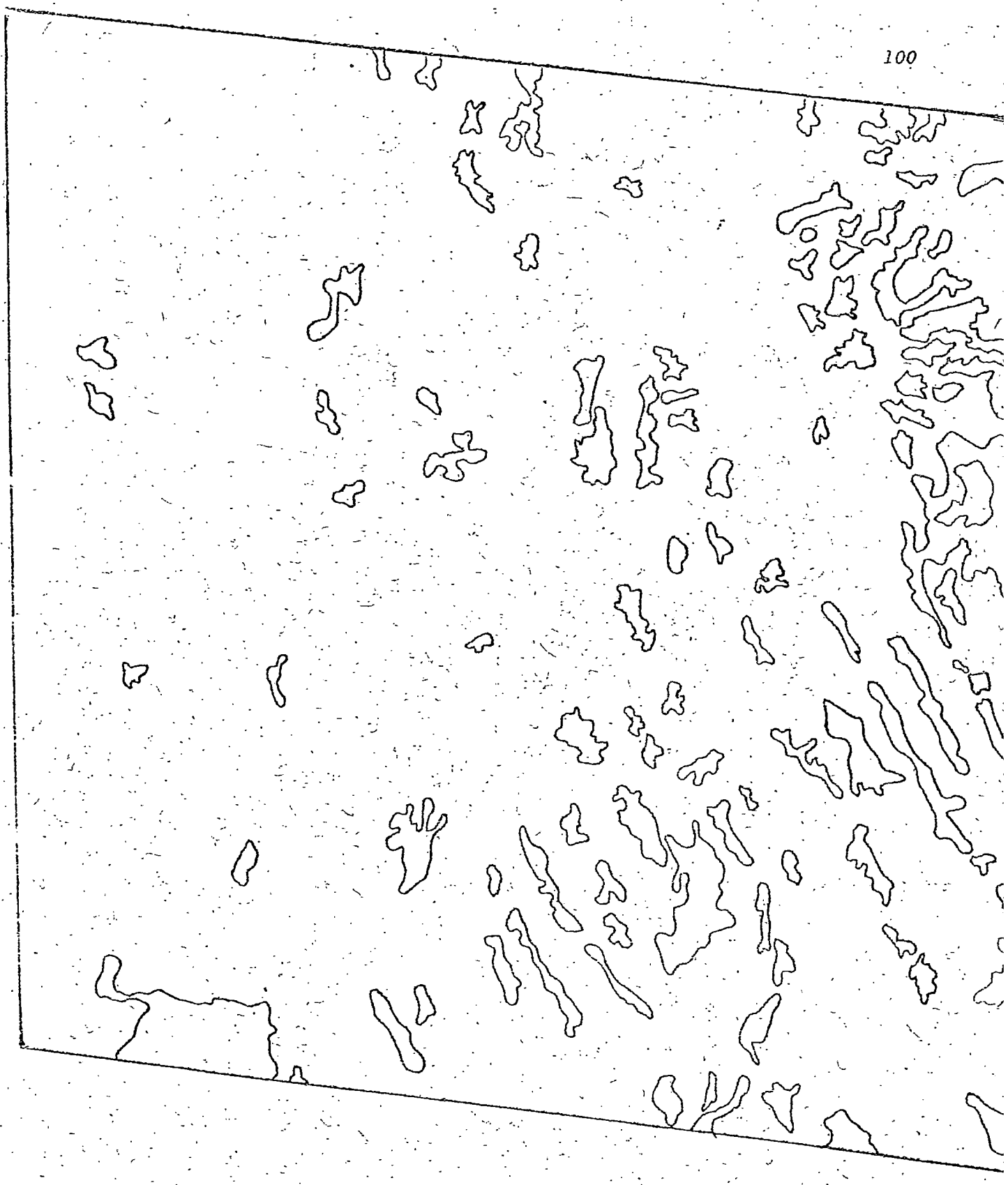


Fig. 33 Generalized Wetland Map

WORTH, New York

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