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LITHOLOGY and ALTITUDE in the GASPÉ PENINSULA, QUEBEC

LITHOLOGY and ALTITUDE
IN THE GASPÉ PENINSULA, QUEBEC.

A preliminary inquiry into frequency distribution analysis of altitude based on lithology as a method of landscape description

by

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" The appeal of brief, vivid, and perhaps poetical expression has led both popular and technical writers to animate the landscape by the skilful use of metaphor. The Seine River in France was once referred to by Davis (1909, p.588) as 'an able-bodied river, a river of robust habit of life'." p. 576

".....there is a general unawareness of our ignorance of some geomorphic processes and the plight is largely the result of metaphor in our geologic thoughts and expressions." p. 577

- Harry E. LeGrand, 1960, Journal
of Geology, v. 68, no. 5.

CHAPTER I

INTRODUCTION

1.1 Objectives.

The correlation between the altitude of an erosional topography and the underlying bedrock is much assumed and has been little tested. Geomorphologists generally agree that bedrock geology has an influence on topography; however, a survey of the literature reveals that the interconnection is thought of as "complex" , and that comments on the relationship are usually couched in vague terms of relative erodibility.

If we define a topography as an infinite population of altitudes, then it is possible to obtain samples for lithologically uniform areas and to study the relationship. Primarily then, this thesis is an attempt to describe a topography in terms of frequency distributions of altitude based on lithology.

The following are detailed objectives:

a)- The quantification of the lithology-altitude relationship of a topography, by frequency distribution analysis of altitude;

b)- Attempt at the derivation of an order of relative erodibility (relative susceptibility to wearing away) for the rock units within the study area;

c)- Consideration of the overall topographic system.

Most topographic analyses are controlled experiments with many landform parameters either held or assumed constant and the variability of one or few parameters observed. Similarly, this study is such an experiment, by adoption of a model which has lithology as an independent variable and topographic altitude a directly dependent variable.

1.2 Survey of the literature.

Quantitative considerations of lithology relative to landform and its development are not numerous in the literature, while qualitative views are abundant. A sampling is presented:

De la Noë and de Margery (1888, p. 24), in their book "Les Formes du Terrain", consider both topography and slope development dependent on rock type.

Gilbert (1877), in his celebrated Henry Mountains report, speaks of a "law of structure".

p. 108: "Insofar as the law of structure controls sculpture, hard masses stand as eminences and soft are carved in valleys."

William Morris Davis believed lithology and structure less important than erosion. He writes (Davis, 1884):

p. 428: "The relations of a number of geographic forms may be exhibited by means of a classification based first on the peculiarities of structure and second on the amount of erosion that they have suffered."
"....of greater geological importance than these early and constructional characteristics, are the later destructional ones, determined by erosion, inasmuch as they comprehend the topographical form that we usually observe."

In his treatise on the Triassic geology of Connecticut, Davis (1897) observes: "....a complete lack of sympathy between structure and form."

Fenneman (1936), in discussing cyclic and non-cyclic erosion, writes:

p. 92: "Theory would indicate that the rate of erosion without valleys should vary with the hardness of rock and the width of outcrop, the latter being determined by thickness of stratum and dip. Even a casual examination of the Appalachian ridges is sufficient to indicate that such correlations of altitude with structure exist."

On the same page he comments further:

> "When an equal amount of exact study shall have been given to correlating each height with the character of rock and the breadth of outcrop, the time will have come to decide how many levels must be assumed."

Ashley (1935), in Pennsylvania, questions multiple peneplain criteria and emphasizes the effects and importance of structure and differential erosion in producing "....apparent summit accordances...."

Cole (1935; 1937) writes on rock resistance and structural control of erosion surfaces in eastern and southern Ohio and adjacent Pennsylvania and West Virginia. He considers (Cole, 1935), that:

> p. 1049: "The surface configuration....is governed by varying resistance and attitude of strata which have been differentially sculptured during four cycles of erosion."

Thompson (1941) provides a detailed analysis of the relation of topography to bedrock, for parts of Virginia.

> p. 529: "The number of summits per unit area of outcrop is another indicator of relative resistance of the formations. By noting the average altitude of the summits and the number of summits per unit area of outcrop on each formation, one might arrive at a fairly accurate scale of relative resistance of the various rocks."

Thompson believed strongly in the importance of bedrock and structure as physiographic controls:

> p.537-539: "It seems superfluous to consider an upland or summit peneplain if the various altitudes of the ridges can otherwise be satisfactorily explained. The following factors are believed to account sufficiently for the various altitudes of the ridges: (1) different rock formations, (2) structure, (3) width of outcrop of ridge-makers, (4) altitude of anticlinal folds, and (5) nearness to main streams."

Hack (1960), promoting the concept of dynamic equilibrium in humid temperate landscape evolution, presents a view which has found acceptance by many modern geomorphologists:

> p. 35: "....forms and processes are in steady state of balance and may be considered as time independent. Differences and characteristics of form are therefore explainable in terms of spatial relations in which geologic patterns are the primary consideration...."
>
> p. 91: "Differences in form from one area to another, including the relief, form of the stream profile, valley cross-sections, width of floodplain, shape of hill tops and other form elements are explainable in terms of differences in the bedrock and the manner in which it breaks up into different components as it is handled on the slopes and in the streams."

Bretz (1962) and Holmes (1964) find little correlation between lithology and topography. They cite examples from the Missouri Ozarks and western North Carolina respectively, reject dynamic equilibrium, and write in support of the Davisian system. Holmes observes:

> p. 440: "Across outcrop areas of weak rock, valley floors up to half a mile across in width have been developed; whereas across the intervening resistant zones the valley floors are narrow or of only channel width through distances up to 2 miles... ...These relationships indicate considerable differences in rock resistance to weathering and erosion....but the most significant fact is that, except for three conspicuous monadnocks, the uplands are all but completely devoid of any recognizable topographic expression of these obvious differences in rock resistance."

Howard (1965) presents a review of current concepts of geomorphological systems and notes severally the importance of lithologic considerations:

> p. 304: "Among both historical and equilibrium schools there has been a widespread tendency to consider the effects of stratigraphy and structure upon landforms to be secondary and even temporary influence....more reasonable is the expectation that all variations of stratigraphy and structure will find continuous expression through form and process variations in the landscape."

Again, he writes:

> p. 305: "Stratigraphy and structure act passively upon landforms, exerting influence through constraints upon the system and, in the case of stratigraphy, as a source of mass for the system. In areas where lithology and structure are of constant composition or only slowly varying in the vertical direction, a complete adjustment between landforms and geology is to be expected, and such a case is indicated by the well defined correlation between stream and slope parameters and the parental material in areas of steep regional dip or locally homogeneous lithology."

Quantitative studies of the relationship of landform elements to lithology and structure are few in number.

Bryan (1922), Strahler (1950b), Melton (1957) and Hack and Goodlett (1960) have commented on valley-side slope development in areas of different lithology. Strahler finds no correlation:

> p. 806: "Because the two areas of similar rock differ significantly in slope, whereas two of the unlike areas do not differ significantly in slope, we may conclude that some factor (or factors) other than bedrock has a controlling influence on slope differences....A possible explanation for a lack of any strong bedrock influence may be the deep weathering of bedrock in this region."

Melton obtains a definite correlation:

> p. 37: "The valley-side slopes of drainage basins vary with lithology, being steepest on shale and perhaps limestone, and gentlest on schist and acid volcanic lithologies."

Hack and Goodlett fitted mathematical equations to the profiles of slopes underlain by specific rock types.

Wolman (1955), Hack (1957), Miller (1953; 1958) and Hely and Olmstead (1963) have discussed stream gradient, drainage pattern and density, and drainage basin shape in relation to lithology. Brush (1961) has considered in detail the hydraulic geometry of sixteen selected streams in central Pennsylvania ; he relates stream channel parameters to lithology and observes that:

> p. 145: "The type of bedrock underlying the channels included in this study appears to affect both channel slope and particle size. For a given length of stream, a stream channel underlain by sandstone, tends to have a steeper slope and larger bed material than channels underlain by shale or limestone. Hence, a stream which heads in sandstone and ends in limestone, tends to have a more rapid decrease in slope and particle size than a stream heading in limestone and ending in sandstone."

Miller (1961) sampled solutes in small streams draining single rock types in the high Sangre de Cristo Mountains, in New Mexico and found that:

> p. F23: "The approximately uniform concentration of solutes in waters draining single rock type indicate a steady-state relation for weathering mechanisms...."
>
> p. F21: ".....it seems very unlikely that erosion surfaces can be preserved unaltered for millions of years.....the curves.....indicate that 1 million years of weathering at 10,000 feet could cause sandstone terrains to be lowered 48 feet, granite terrains by 11 feet, and meta-quartzite terrains by 3 feet. Thus solution weathering alone would considerably lower any surface and in lithologically contrasting areas would produce rugged relief within a few million years."

Flint (1963) studied the relation of altitude and stream pattern to lithology in Connecticut, through topographic map analysis. Limiting his considerations to crystalline rocks, he obtains frequency distributions of altitudes from grid-point sampling and calculates sample parameters. He concludes that:

> p. 690: ".....agreement between lithology and altitude is good. Rocks that, because of their mineral content, could be expected to resist erosion effectively, underlie areas of relatively high altitude and rocks that are rich in erodible minerals underlie lower areas."
>
> "This relationship between altitude and lithology.....seems compatible with the concept, set forth by Hack (1960)...."

V.C. Miller and C.F. Miller (1961) note from wide experience in the field of photogeologic analysis:

> p. 81: "Differential erosion is considered the first key to bedrock identification and interpretation on aerial photographs. In any area subjected to prolonged erosion (principally by running water), resistant rocks may be expected at or near the surface of higher topography, with less resistant rocks in lower topographic positions (i.e., sandstone ridges and shale valleys)."
>
> "In relatively few instances such a topographic -lithologic correlation does not occur."

1.3 Location of the area of study.

The Gaspé is situated in the Province of Quebec (fig. 1, p. 8). It is the peninsular landmass that extends east of the Matapedia River into the Gulf of St. Lawrence, being bounded on the north by the St. Lawrence River and on the south by Chaleur Bay.

This study is confined to the western half of Gaspé — the topographic region between the Matapedia and the Cascapedia Rivers. The area is approximately bounded by latitudes 48°00' to 49°15' North and longitudes 66°00' to 67°30' East.

1.4 Considerations in the choice of area.

The Gaspé was chosen for this study because it is believed to be a good example (probably the best example in Canada) of topography which has evolved under the dominant influence of fluvial processes alone.

Probably the region was completely covered by glaciers, during the Wisconsin maxima (McGerrigle, 1952) but it is thought that the mountains forming a high northern rim[1] kept erosion by the Labrador ice sheets to a negligable minimum in the interior.

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[1] - The height of the northern mountains ranges up to 4160 ft above sea level for Mont Jaques Cartier in the Tabletop block and is commonly 3000-3700 ft in the Shickshocks.

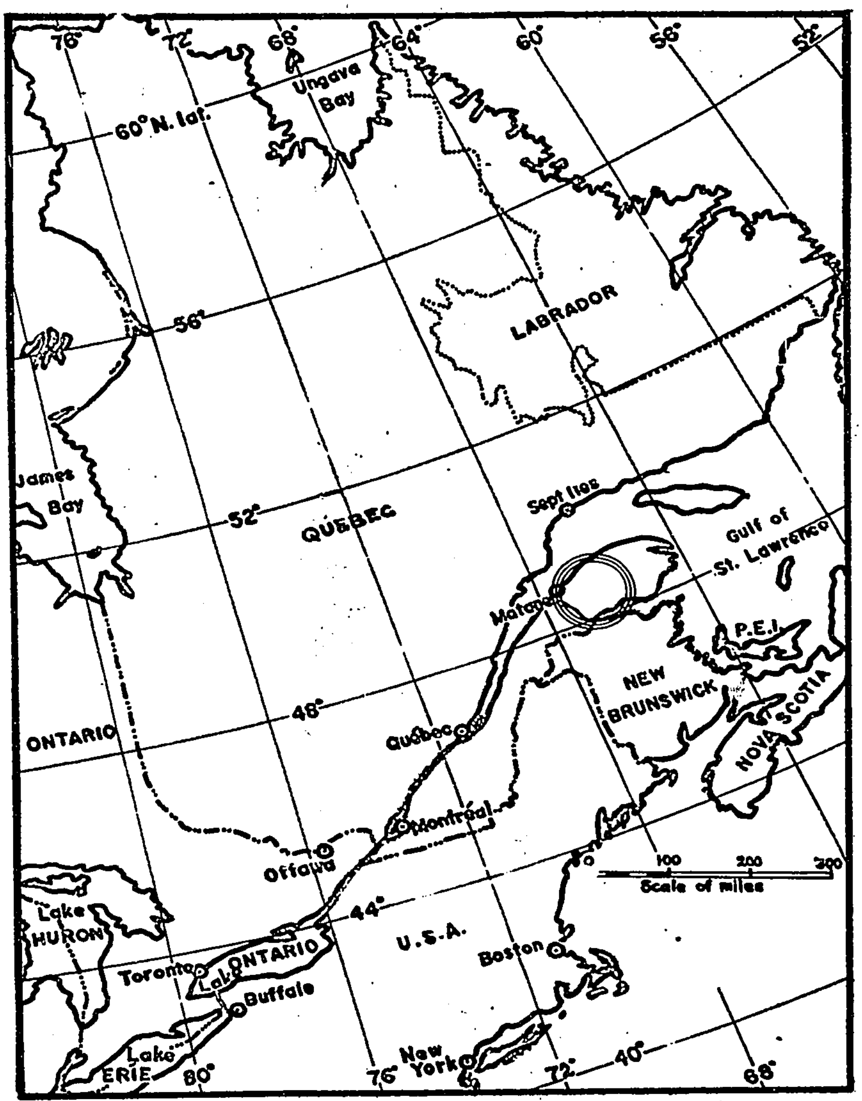

Figure 1 .-Location of Gaspé Peninsula.

There is a variety of geologic units present in the Gaspé, with good areal continuity of outcrops. The structural trend is strikingly regular.

Finally, over most of Canada, the best available topographic map coverage is at the scale of 1:50,000 with 50 ft contour interval. For maps of this series, depending on the method of plotting and the type of ground-control available at the time of the survey, altitudes depicted by contours can differ from the represented absolute values, by as much as one half to two times the contour interval (personal communication, A.C. Tuttle[2], 1965). The greater the amount of relief of an area, the less would be the effect of accrued mapping errors. With local relief of more than 1,000 ft found commonly, the Gaspé is a good choice for the type of mapping available.

1.5 Fieldwork and acknowledgements.

The problems discussed in this thesis are mainly theoretical, and the main starting point is from map analysis. Sometimes, such studies can be somewhat unrealistic if not complemented by field observations. The writer was able to visit the Gaspé twice: for three months during the summer of 1965, as assistant party-chief of a Quebec Department of Natural Resources geological field crew, mapping the western contact and metamorphic zone of the Tabletop granite intrusive; and also for a brief but concentrated two-week reconnaissance field trip, in the Fall of 1964.

I would like to thank the Province of Quebec Department of Natural Resources, for supporting this work, through the granting of two post-graduate scholarships.

Also, sincere thanks are conveyed to Dr. J. Beland, of the Université de Montreal, who discussed and pointed out

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2 - Chief Topographical Engineer, Canadian Topographical Survey, Department of Mines and Technical Surveys, Ottawa.

several problems of Gaspé geology.

Dr. W.B. Skidmore, geologist of the Quebec Department of Natural Resources, corresponded on the subject of his unpublished field work in the Rivière Angers East and Escuminac map-areas, and kindly made available copies of unpublished maps.

Dr. J.A. Elson served as the faculty advisor, and imparted an enthusiasm for the subject of geomorphology, for which I am very grateful.

Miss M. Loctus of Montreal and Mrs. A. Jürisson of St. Catharines, Ontario typed various parts of the manuscript. All drawings and illustrations were prepared by the author.

CHAPTER II

GEOLOGY and PHYSIOGRAPHY of GASPÉ

2.1 General Geology.

2.1-(1) Introduction.

Study of the geological setting of Gaspé Peninsula was begun by Sir William Logan, in 1843, as part of the first field program of the Geological Survey of Canada (Logan, 1844, 1846, 1863). Subsequently, studies were undertaken by both the Geological Survey and the Québec Dept. Mines (now renamed: Department of Natural Resources). A summary of the work is given by Dresser and Denis (1944, p. 345-391).

Coleman (1921), Parks (1931), and McGerrigle (1954) have written brief syntheses of the general geology of Gaspé. McGerrigle (1953), compiled the basic geologic map of the Peninsula (now under revision), at a scale of four miles to one inch.

Some detailed studies have been undertaken within the framework of M.Sc and Ph.D. theses. Carbonneau (1953), Mattinson (1958), McGregor (1961; 1964), and Ollerenshaw (1963) have mapped parts of western Gaspé in the course of theses studies.

2.1-(2) Geological setting.

The Gaspé Peninsula is part of the northern Appalachian mountain system and is underlain by Paleozoic rocks of Cambrian to Pennsylvanian age. The sedimentary rock units trend in a northeasterly direction, which swings to easterly from central Gaspé to the Gulf of St. Lawrence (Gaspé Salient).

According to Neale, Beland, Potter and Poole (1961), only two orogenies have effectively formulated the structural elements of the region: the Taconic, of Middle and/or Late Ordovician time, accompanied by ultrabasic intrusives; and the Acadian, of about Early Devonian time, with emplacement of granites.

2.1-(3) Belts of similar geological setting.

Western Gaspé can be divided into four east-west trending, geologically-similar belts, after McGerrigle (1954), (figure 2, p. 13):

a)- Northern belt: This is a ten to twenty-five mile wide zone of folded Cambrian and Ordovician rocks - predominantly shales and slates, and minor quartzite, limestones and phyllite. It extends from the north shore to the foot of the Shickshocks.

b)- North-central belt: This belt is six to eight miles wide and coincides with the Shickshock topographic high. It is underlain by altered basic volcanic rocks and minor metarkoses and is considered to be of Cambrian or Cambro-Ordovician age (Ollerenshaw, 1963, p.33). The Mont Albert ultrabasic intrusive and the Tabletop granite belong in this belt.

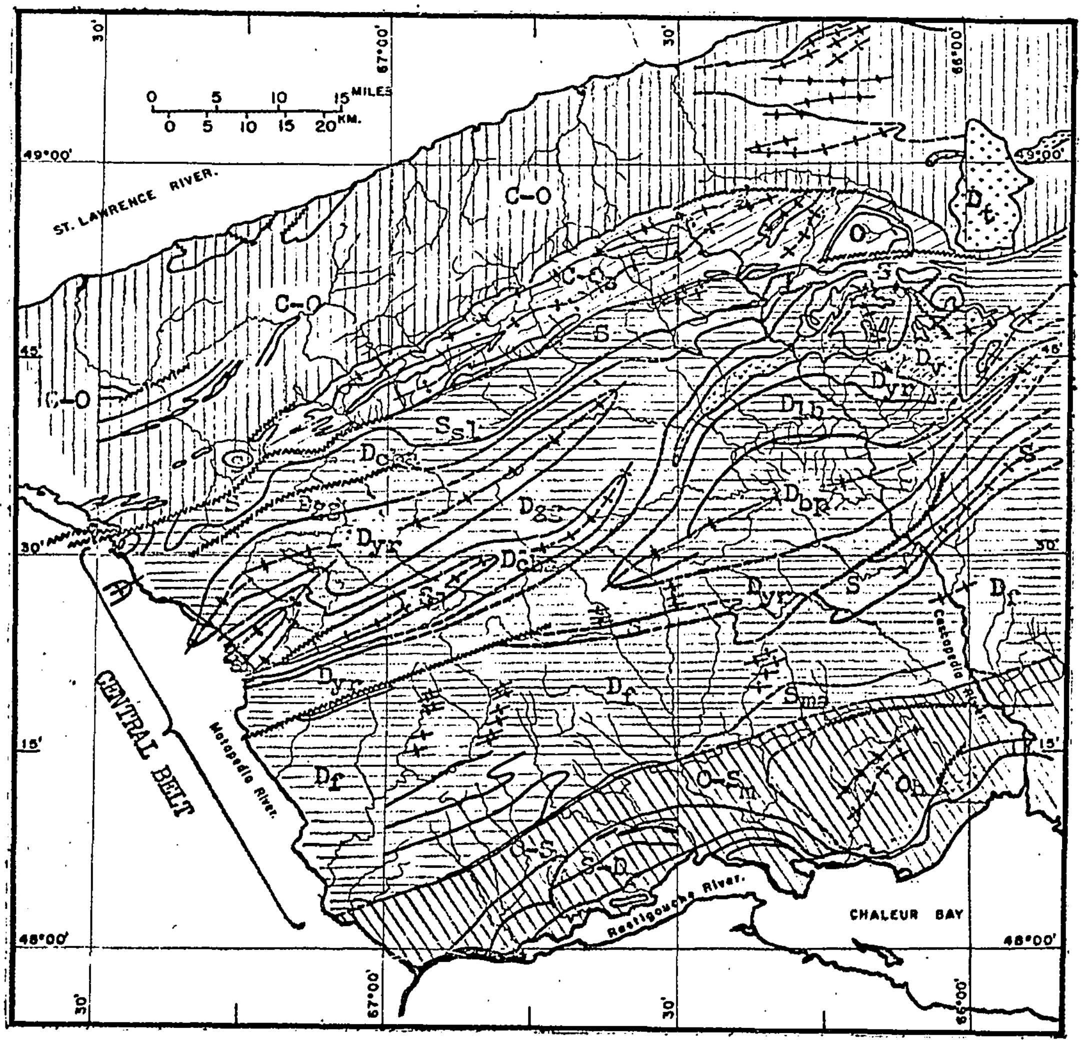
c)- Central belt: This belt is about fourty miles wide and is underlain by Devonian and Silurian strata forming the "Central Gaspé Basin" or "Gaspé Syncline". A variety of sandstones, micritic limestones, shales and siltstones are found. The north boundary of the belt is marked by fault contact with the Shickshock group rocks.

d)- Southern belt: In western Gaspé, the southern belt is a zone of folded sedimentary rocks of Cambro-Ordovician to Silurian age, with some Silurian and Devonian volcanic rocks.

2.1-(4) Structural features.

Structural features within the individual belts are considered to be of a similar origin, after Neale, Beland, Potter, and Poole (1961) - i.e., all formations making up any one belt are thought to have had a fairly similar tectonic history: the North and North-central belts were affected mainly by the Taconic orogeny; the Central belt only by the Acadian disturbance; and the Ordovician rocks of the Southern belt in both. The above is somewhat of a generalization, and the interested reader is referred to Ollerenshaw (1963, p.287-289) for a more detailed review.

There is no evidence for a late Paleozoic orogeny in the western Gaspé. and the area can be considered a stable



NORTHERN BELT	NORTH-CENTRAL BELT	CENTRAL BELT	SOUTHERN BELT
▥	▨	▤	▧

LEGEND

D - Devonian.
- bp- Battery Point fm
- lb- Lake Branch fm.
- yr- York River fm
- f- Fortin gr
- gg- Grande Grève fm
- cba- Cape Bon Ami fm
- v- volcanics
- t- tabletop granite

S-D - Silurian and/or Devonian.
- r- Restigouche gr

S - Silurian.
- sl- St Leon fm
- ma- Mt Alexandre gr

O-S Ordovician and Silurian.
- m -Matapedia gr

O - Ordovician.
- h -Honorat gr

C-O Cambrian and Ordovician.
- q -Quebec gr
- s -Shickshock gr

Figure 2 - General geology of Gaspé Peninsula. (see also: index map-9, in back pocket).

cratonic block since the close of Acadian orogenic time, at about the Middle Devonian.

The structure of the northern belt consists of a series of tight, frequently isoclinal folds, with north-northeast trending axes. A complex series of normal and thrust faults, generally of undeterminable displacement, are found throughout. Cleavage is vertical and closely spaced.

The rocks of the north-central belt are arranged in a double fold - a northern anticline and a southern syncline; the structure is present the length of the Shickshock block. A strong primary foliation, with a strike of N.60°E., is present throughout.

A major fault, named the "South Shickshock Fault" by Ollerenshaw (1963), separates the north-central belt from Silurian strata of the central zone.

Within the broad central belt, bedrock is much less deformed than in the two previously described zones. Although the Fortin Group has a complex structure, the other formations are in broad, open anticlines and synclines. The Fortin sequence has a marked steeply-dipping to vertical schistosity throughout. The Cape Bon Ami has a characteristic fracture cleavage; the Grande Grève is generally well cleaved, but less so than the Cape Bon Ami.

In the southern belt, the Ordovician rocks of the Matapedia Group have a marked steeply dipping to vertical schistosity; bedding is generally steeply dipping to vertical.

2.2 Descriptions of sampled formations.

The altitude sampling of lithologies found in the western Gaspé is based on rock units at the formation or group level. Each unit will be described briefly, below.

NORTHERN BELT

2.2-(1) The Québec Group.

Parts of the geology of the northern belt are known from reconnaissance mapping by McGerrigle (1954), Beland (1957), and from more detailed study by Ollerenshaw (1963).

BELT	FORMATION or GROUP		AGE	MAP AREAS and
Northern	Quebec gr		Cambro-Ordovician	(1)-1.
North-central	Shickshock gr		Do	(1)-2
	Tabletop granite intrusive		(Lower) Devonian	(2)-2,2A,2B.
	Mont Albert ultra-basic intrusive		Ordovician	(2)-1.
Central	Battery Point fm		Middle Devonian	(3)-6.
	Lake Branch fm		Do	(3)-5,5A,5B,5C,
	York River fm		do	(3)-4,7; (4)-1;
	Ste Marguerite volcanics		do	(7)-10.
	Devonian volcanics (unnamed)		Do	(3)-3.
	Fortin gr.	shaly facies	Lower and/or Middle Devonian	(6)-1,3; (7)-1
		silty facies	Do	(6)-4.
		sandy facies	do	(6)-2.
		undifferentiated	Do	(4)-3.
	York Lake facies		Lower Devonian	(3)-2.
	Grande Grève fm		Do	(1)-5; (3)-1;
	Cape Bon Ami fm		Do	(1)-4; (7)-3;
	St Leon fm		Upper Silurian	(7)-4,5; (8)-1
	Silurian (undifferentiated)		Silurian	(1)-3.
Southern	Restigouche gr.	mudstones	Silurian and/or Devonian	(6)-6,6A,6B.
		basic volcanics	Do	(6)-7,7A,7B.
		undifferentiated	Do	(5)-3.
	Mont Alexandre gr		Upper & Middle Silurian	(4)-4.
	Jonathan fm		Upper Silurian	(4)-2.
	Matapedia gr		Ordovician & Lower Silurian	(4)-5; (5)-2;
	Honorat gr		Ordovician	(4)-6; (5)-1.

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117; B-5, p.115.	C-4, p.125; C-5, p.125.

Table 1.

Cross index to geological units and sampled frequency distribution data.

The variety of lithologies which are found are collectively named the Quebec group, after Logan, who mapped these rocks from Levis to the Gaspé. Attendant difficulties in using this "dust-bin" term are discussed by Ollerenshaw (1963, p. 19-21), who suggests, for various reasons, the term "St. Lawrence Complex". For the purposes of this thesis, the name Quebec group, will be retained.

The rocks are predominantly grey, green and red shales and slates, and phyllitic shales; calcareous siltstones, minor grey limestone, limestone conglomerate and quartzite are also found.

NORTH-CENTRAL BELT

2.2-(2) The Shickshock Group.

Two main rock types are found: grey-green, fine grained, metamorphosed lavas (albite-epidote-amphibolite schists), with locally conspicuous plagioclase phenocrysts; and minor metasedimentary rocks (metarkoses with coarse grained quartz, and pink and white feldspars). Mattinson (1958, p. 185-187) recognized four subtypes of the metavolcanic sequence. Epidote, calcite, and quartz veins are found in appreciable quantity throughout.

2.2-(3) Tabletop Granite Intrusive.

Jones (1933) described the geology of the Tabletop granite as follows: mainly medium to coarse grained pink granite, and grey medium grained (to locally porphyritic) diorite and granodiorite; some medium grained red syenite, and minor fine grained (to sugary) pink felsite, quartz-feldspar pegmatite, and granite porphyry.

The intrusive has a contact metamorphic border-zone of altered sedimentary rocks: tough, brittle, dark brown to black hornfels; greenish-grey to white, ultrafine grained porcellinite; and green to brown garnetiferous skarns.

2.2-(4) Mont Albert Ultrabasic Intrusive.

A general description of the intrusive is given by Alcock (1926, p. 35-38), while MacGregor (1961; 1964) treats the body in more detail.

The central part of the intrusive is composed of dunite and peridotite, with minor amounts of pyroxenite, serpentinite and chromitite.

The body is surrounded on the east, north and west by a contact metamorphic rim of dark-colored hornblendic rocks. On the south, the intrusion rests in fault contact with the Shickshock group rocks. A Potassium-Argon age determination on two micas from a sample of the contact metamorphic zone, has given an age of 495 M-yrs. This indicates a probable Ordovician age of recrystallization; evidence of a further recrystallization is lacking.

CENTRAL BELT

2.2-(5) Battery Point Formation.

McGerrigle (1950), suggested the name for rocks first described by Logan (1863, p. 416), at Tar Point, in eastern Gaspé.

In western Gaspé, the formation is exposed in the Big Berry Mountains area and was described by Carbonneau (1959, p. 37) as: medium to light greenish-grey, fine to medium grained (some very coarse grained) sandstones, with up to 20% interbedded shale.

The average composition of the Battery Point sandstones is given by Carbonneau as: 51.5% quartz and chert, 20.6% micas and chlorite and 27.9% feldspar and kaolin. The Battery Point sandstones are termed greywacke sandstones in this study.

2.2-(6) Lake Branch Formation.

The formation has been described by Carbonneau (1959, p.33-35) in the Big Berry Mountains area and by Stearn (1959, p. 7) in the Causapscal East area.

Carbonneau describes the formation as made up of generally dull to bright red, well-bedded but poorly consolidated shale, with some siltstones and fine grained argillaceous sandstones.

Probably a deltaic deposit, the Lake Branch redbeds grade into the underlying York River sandstones, through an interfingering transition zone and the formation can be considered as a red facies of the York River formation.

2.2-(7) York River Formation.

The York River beds were named by Williams (1910) and are described for parts of western Gaspé by: Carbonneau (1953, p. 68; 1959, p. 28), Stearn (1959,MS), Skidmore (1960), and Ollerenshaw (1963, p. 272). Ollerenshaw writes:

> "The sandstones of the York River Formation in the Cuoq-Langis area are mainly intermediate in composition to arkose and feldspathic or high rank greywacke. Some are lithic sandstones. Quartz is the main constituent and forms 40-50% of the rock. Feldspar content averages 20-30%.....Weathered sandstones of the region can readily be recognized as York River by their characteristic whitish weathered feldspar grains."

As described by Carbonneau, the rocks are:

> ".....greenish-grey, medium to fine grained, feldspathic sandstones with numerous interbeds of greenish-grey shale up to 100 feet thick."

The York River sandstones can be distinguished from the Battery Point sandstones by the grey color of the feldspars (those of the Battery Point formation are characteristically pink).

2.2-(8) Ste Marguerite volcanics.

Stearn (1959), mapped a narrow zone of volcanic rocks in the Causapscal area. He included these with the Fortin Group and described them as:

> ".....dark green, fine grained, generally amygdaloidal .....augite andesites."

2.2-(9) Unnamed Devonian Volcanics.

Carbonneau (1959, p.26), describes a series of volcanic rocks between the Grande Grève and York River formations, in the Big Berry Mountains area:

> ".....preeminently basic lavas.....greenish, fine to medium-grained diabase followed downward by..... darker and less green diabase with scattered amygdules of calcite.....and olivine basalt."

2.2-(10) Fortin Group.

The Fortin group rocks are exposed in a wide zone (map - 9, in back pocket) in the central belt, and are described by Beland (1958), Stearn (1959) and Skidmore (1960).

Stearn (1959) mapped the following sequence in the Causapscal area:

> "....dark to medium grey, micaceous slate and phyllitic slate with intercalated beds of greywacke several tens of feet thick. Much of the slate is calcareous and a few beds approach the composition of limestone."

Beland (1958, p.7) was able to divide the formation into three facies, in the Oak Bay area: a)- dark grey to black, locally calcareous, phyllitic shale; b)- hard, light colored, thin-bedded siltstones; and c)- grey, medium to coarse grained, locally thin-bedded but commonly massive sandstones.

Skidmore (1960) did not find corresponding divisions in the adjacent Rivière Angers area.

2.2-(11) York Lake facies.

Carbonneau (1959), after Jones (1936), mapped the transitional zone between the Grande Grève limestones and the York River sandstones, as the York Lake facies. Ollerenshaw (1963, p. 267), maintains, however:

> "....the transition does not appear to warrant separation as a distinct formation or facies, but it does raise the problem of where to place the contact."

Most workers have considered the York Lake facies rocks part of the York River formation.

2.2-(12) Grande Grève Formation.

Clarke (1900; 1908) proposed the name Grande Grève for the uppermost strata of Sir Willian Logan's (1863) Gaspé Limestone Series. Within the thesis area, it has been described by Stearn (1959, p. 5-6), Carbonneau (1953, p. 46; 1959, p. 19-21), Ollerenshaw (1961, p. 9; 1963, p. 260-264), and Mattinson (1959; 1964, p. 80).

The rocks are mainly dark to brownish-grey, hard, brittle, very fine grained siliceous limestone, some silty limestone and some calcareous siltstone. The bedding planes are generally 2 to 8 inches apart and separated by thin layers of silty shale.

2.2-(13) Cape Bon Ami Formation.

Clarke (1900) proposed the name. In western Gaspé, Carbonneau (1959, p. 18) mapped these rocks in the Big Berry Mountains area and estimated the lithology as: 60% dark, blueish-grey, soft, locally arenaceous limestone and 40% dark, calcareous shale. Ollerenshaw (1963, p. 18), for the Cuoq-Langis map-area, described the composition from thin-sections as: 60-90% carbonate, 4-40% quartz silt and 5-10% argillaceous material. Stearn (1959, p. 4), in the Causapscal area, found:

> ".....dark grey, argillaceous and locally silty limestone typically closely cleaved and slaty in the more argillaceous layers."

2.2-(14) St Leon Formation.

These rocks are well exposed in the Cuoq-Langis and Causapscal areas and have been described by Stearn (1959, p. 4) and Ollerenshaw (1961, p. 7; 1963, p. 229-244). Stearn describes the lithology as:

> ".....greenish grey, calcareous siltstone in thick or thin beds which weather medium grey and shades of orange grey. Intercalated with the siltstones are minor beds of greenish grey, medium and fine grained sandstone."

2.2-(15) Zone of Undifferentiated Silurian Rocks.

Mattinson (1964, p. 70-78) mapped Silurian strata in the Mount Logan map-area but did not assign formation names. The rocks are: brownish weathering, limy and argillaceous siltstones, grey and shaly limestones, minor dolomites and fine grained orthoquartzite.

SOUTHERN BELT

The geology of the southern belt is known from reconnaissance mapping by Alcock (1935), and quadrangle mapping by Beland (1958) and Skidmore (1960, MS).

2.2-(16) The Restigouche Group.

Beland (1957, p. 4-6) described the Group as:

> ".....complex assemblage of volcanic and sedimentary rocks which may be subdivided into two zones; one on the northwest, made up almost entirely of sedimentary rocks with a minor amount of volcanics; the second, on the southeast, consisting of a thick series of volcanics with but one occurrence of sedimentary rocks."

The sedimentary zone is made up of:

> ".....brown weathering, highly fossiliferous, grey or greenish grey calcareous siltstone (locally a fine grained sandstone), and.....slightly calcareous, massive, grey or green mudstone, locally quite fossiliferous."

The volcanics are:

> "....black, dark grey or dark green, fine grained to aphanitic basic rocks devoid of pillows. A porphyritic facies with reddish or white phenocrysts of feldspar and more rarely small stubs of a black mineral is also common. Abundant amygdules of carbonate, silica (commonly black chalcedony), chlorite and zeolite are widespread in the porphyritic and non-porphyritic facies. Agglomerates and tuffs....are found throughout the belt but more particularly along the margins."

Skidmore (1960, MS) found a similar sequence in the Escuminac area but did not differentiate volcanic and sedimentary zones.

2.2-(17) The Mont Alexandre Group.

Skidmore (1960, MS) mapped rocks of this Group in the Rivière Angers map-area. The rocks are mainly basic to intermediate lavas and grey siltstones; minor limestone, conglomerates, tuffs and agglomerate.

2.2-(18) "Jonathan" Formation.

Skidmore (1960, MS) used this name for a series of medium to fine grained, amygdaloidal to porphyritic, generally ophitic andesite lava flows interbedded with hard acidic tuffs and minor siltstones and sandstones. The rocks are exposed in the Rivière Angers area.

2.2-(19) The Matapedia Group.

Rocks of this Group were described by Beland (1958, p. 4), in the Oak Bay map-area, as:

> "....mostly light to dark grey compact limestones and dark grey calcareous shales. Some of the limestones are shaly and silty. They occur in thin to thick beds that in many places cumulate into thick zones. Thin beds are commonly interlayered with shales."

Skidmore (1960, MS) mapped the same rock types in the adjacent Escuminac and Rivière Angers map areas.

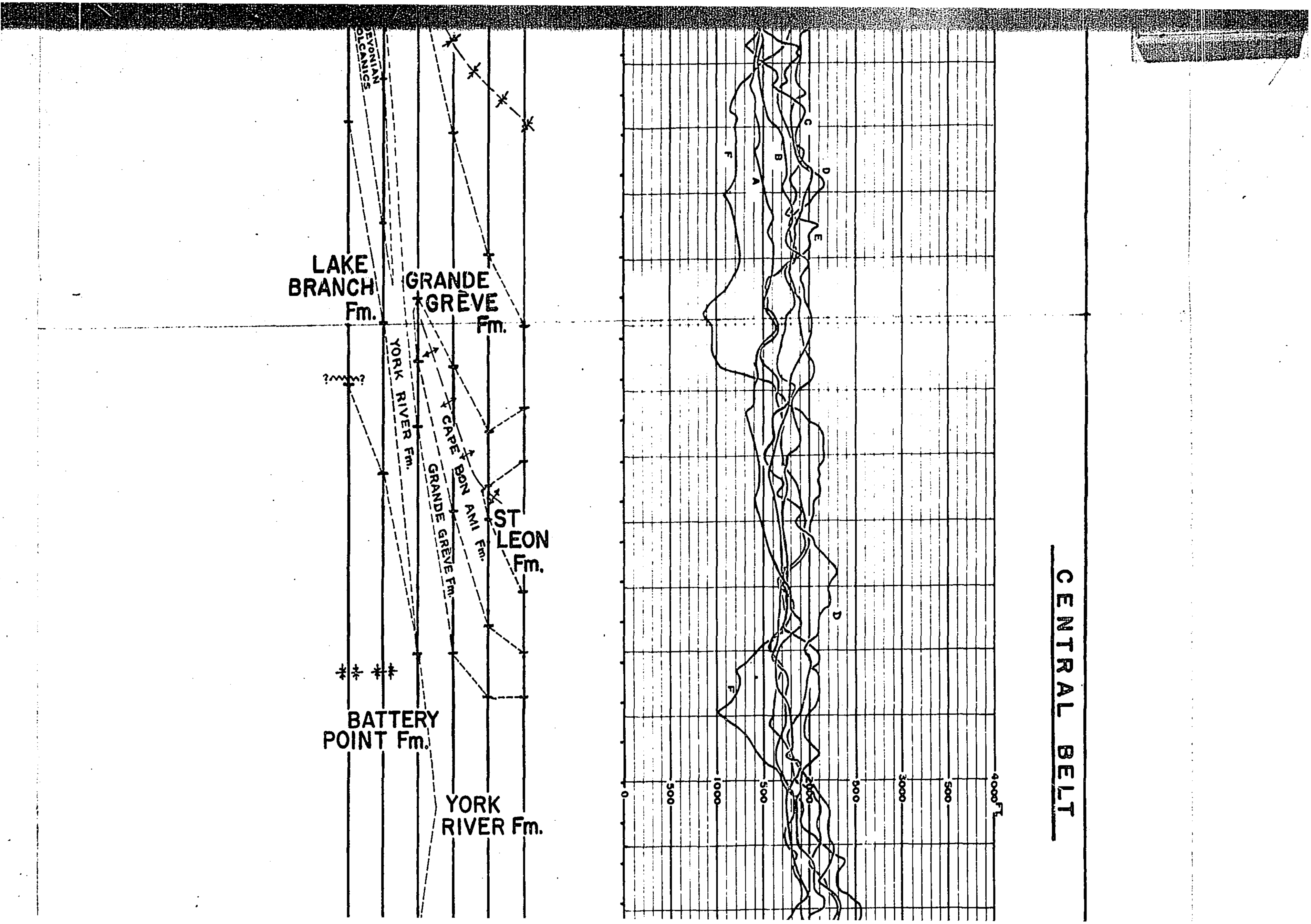
2.2-(20) The Honorat Group.

Skidmore (1960, MS) described these rocks in the Rivière Angers and Escuminac map-areas as: fine to medium grained, grey sandstones and mudstones with minor conglomerate and grey, fine-grained limestones.

2.2-(21) Summary.

The above general and highly qualitative descriptions are the best that are available for rock units mapped in the Gaspé. In addition, it would be desirable to know some of the physical and chemical properties which ultimately determine the resistance of the rocks to erosion. The mapping in the Gaspé is of a very general nature, however, and such data is not available. Thus, we are left with purely subjectively determined units, on which to base the altitude sampling. Betz (1963, p. 194) has put the problem in perspective:

> "....the measurement of the location, distribution, and orientation of units of rock are examples of the long use of numerical data in geology. However, the rocks are defined by physical and chemical properties, not by these 'observational' measurements. Some of the properties are examined quantitatively, but others are not or cannot be. The rock type is, therefore, defined by mixed quantitative and qualitative data. Furthermore, the unit of rock that is mapped is established on a qualitative interpretation or judgment of unity, represented either by homogeneity or some peculiar heterogeneity of components."


DEVONIAN VOLCANICS
LAKE BRANCH Fm.
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YORK RIVER Fm.
CAPE BON AMI Fm.
GRANDE GRÈVE Fm.
ST LEON Fm.
BATTERY POINT Fm.
YORK RIVER Fm.
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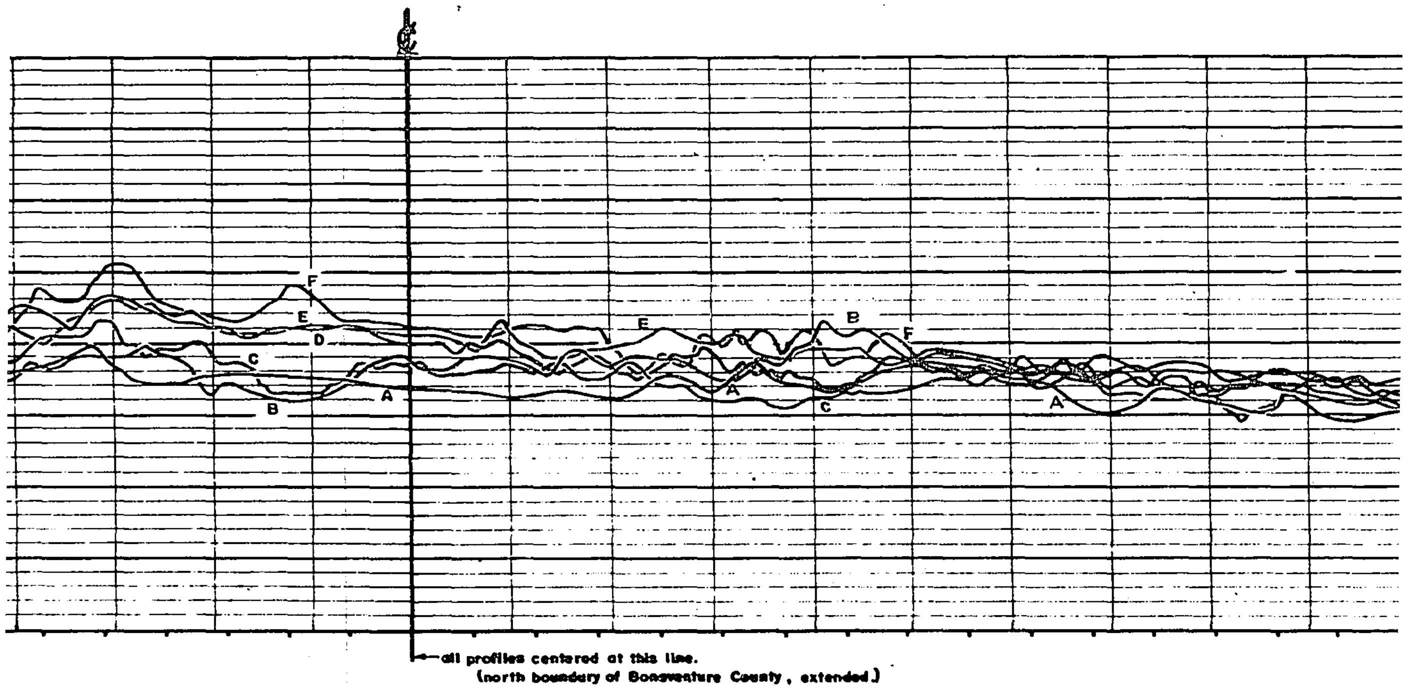
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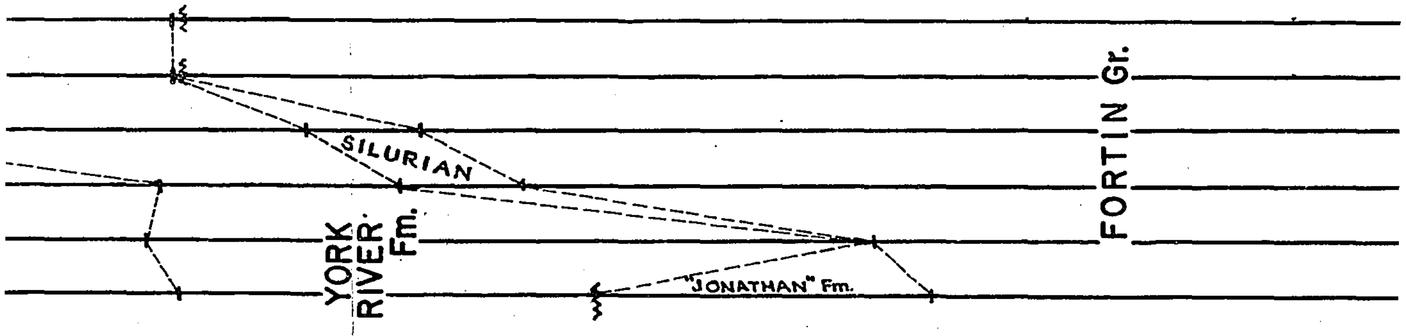
all profiles centered at this line.
(north boundary of Bonaventure County, extended.)


SILURIAN
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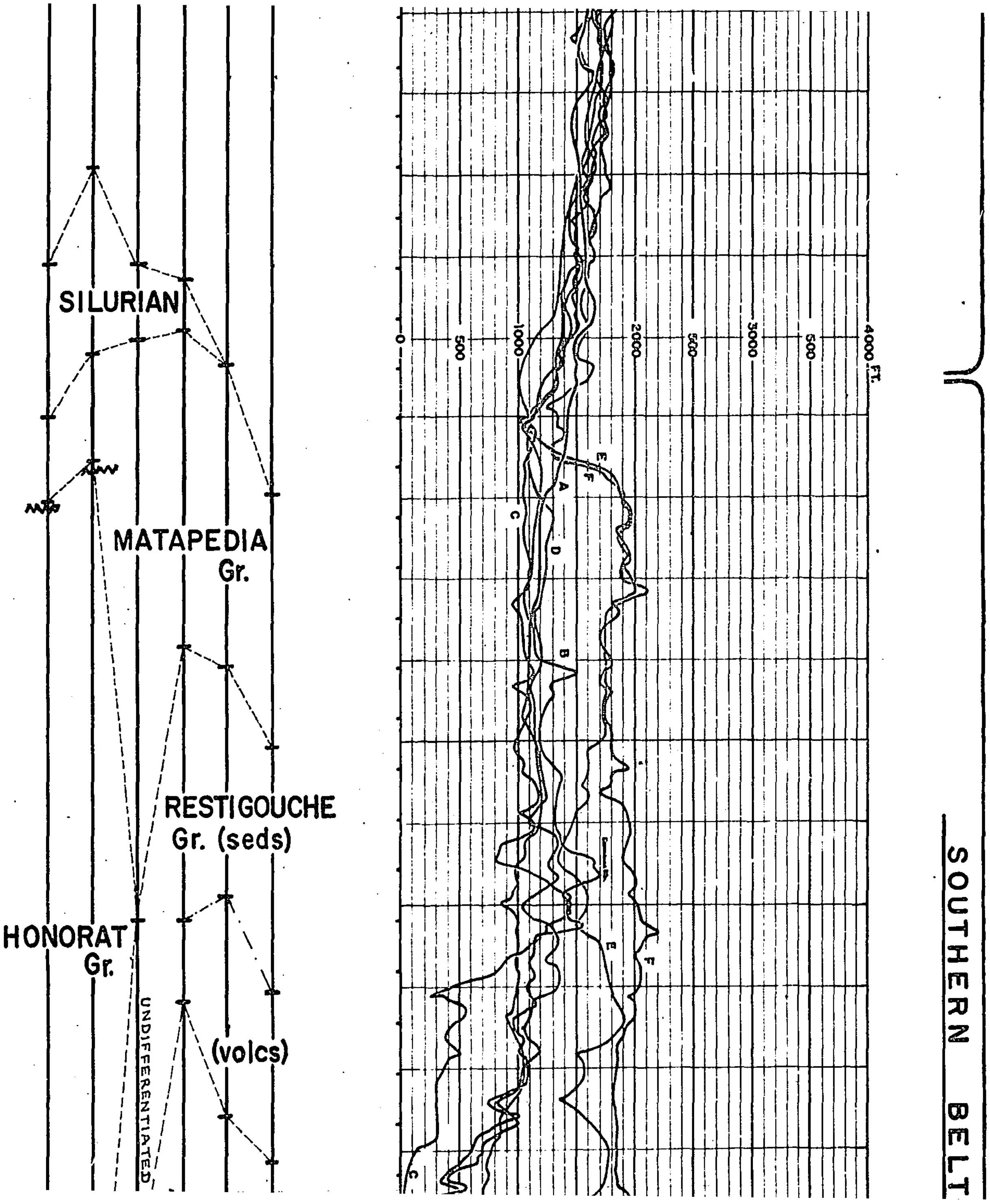
FORTIN Gr.
"JONATHAN" Fm.


SILURIAN
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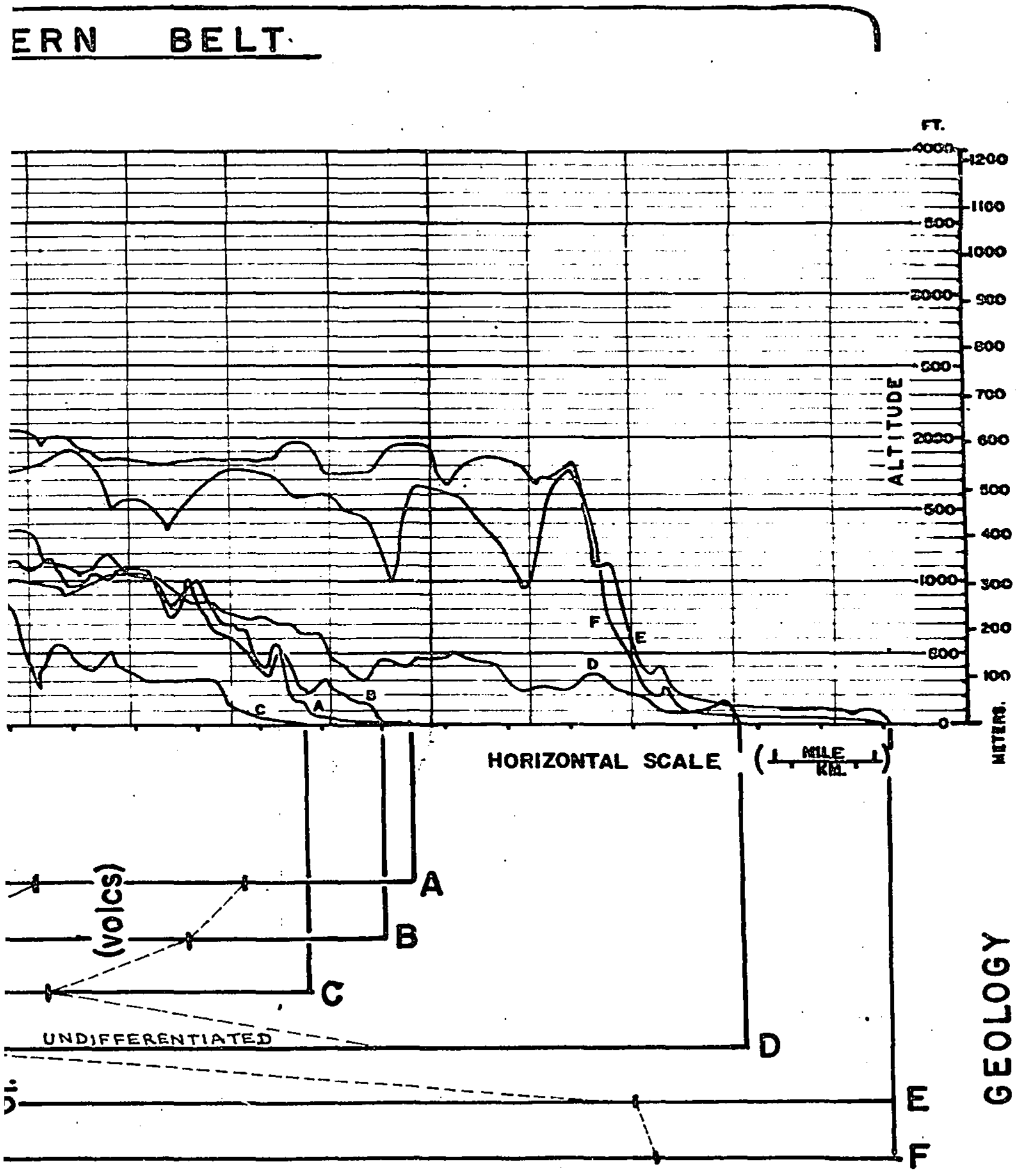
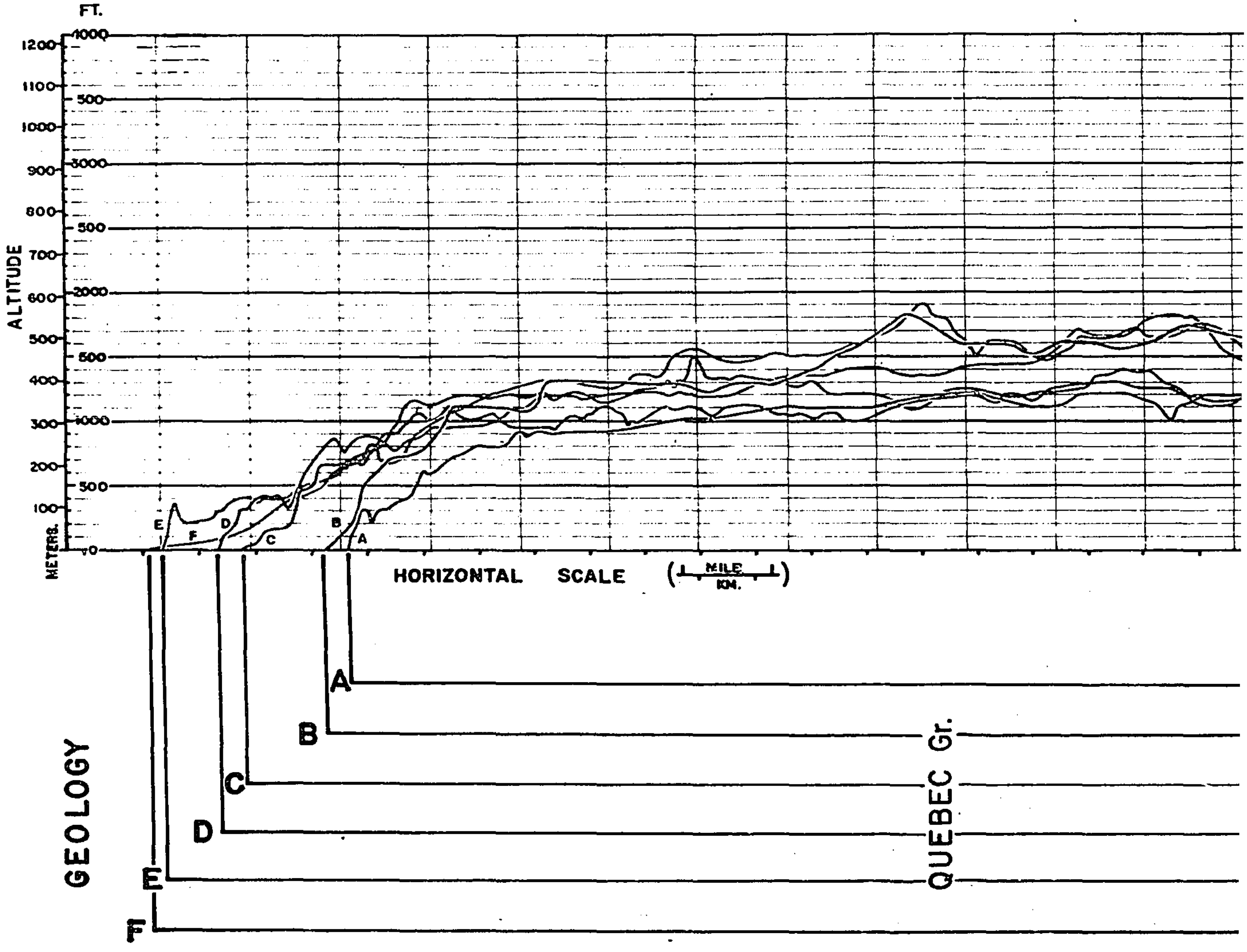


Figure 3 - Superimposed projected profiles and approximated bedrock geology for part of western Gaspé (see map-9 (index) for location of sections).

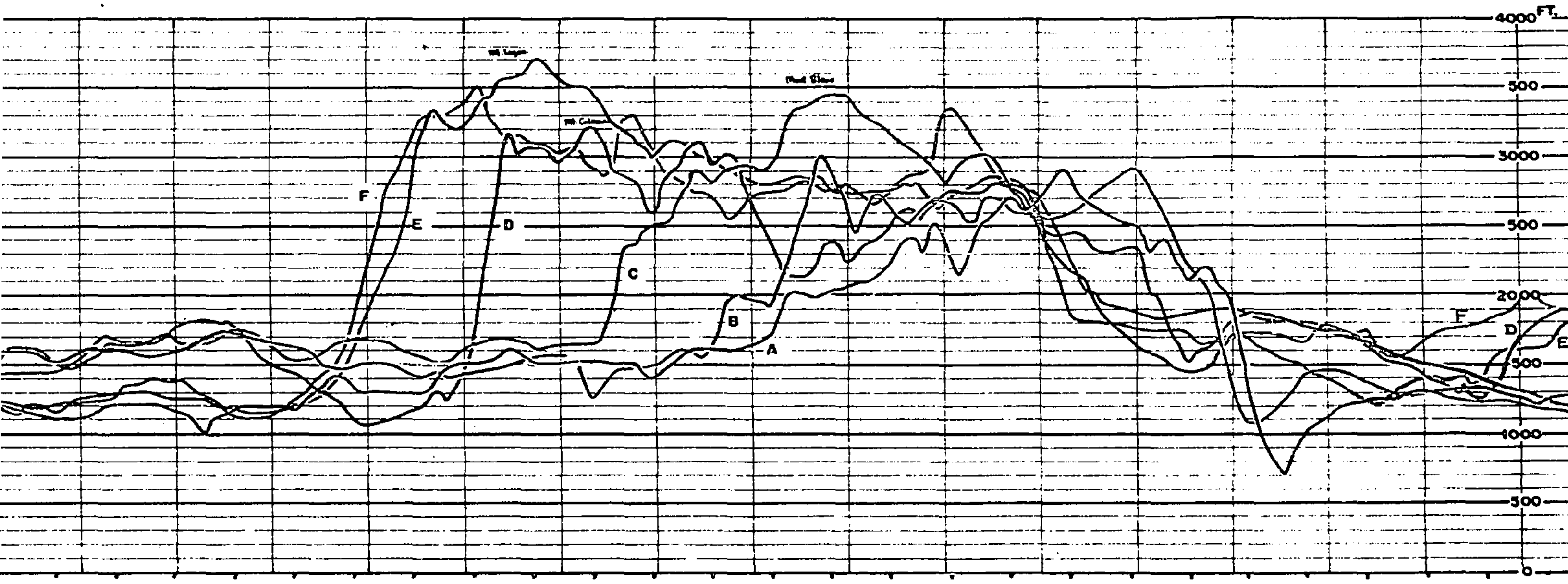
NORTHERN BELT

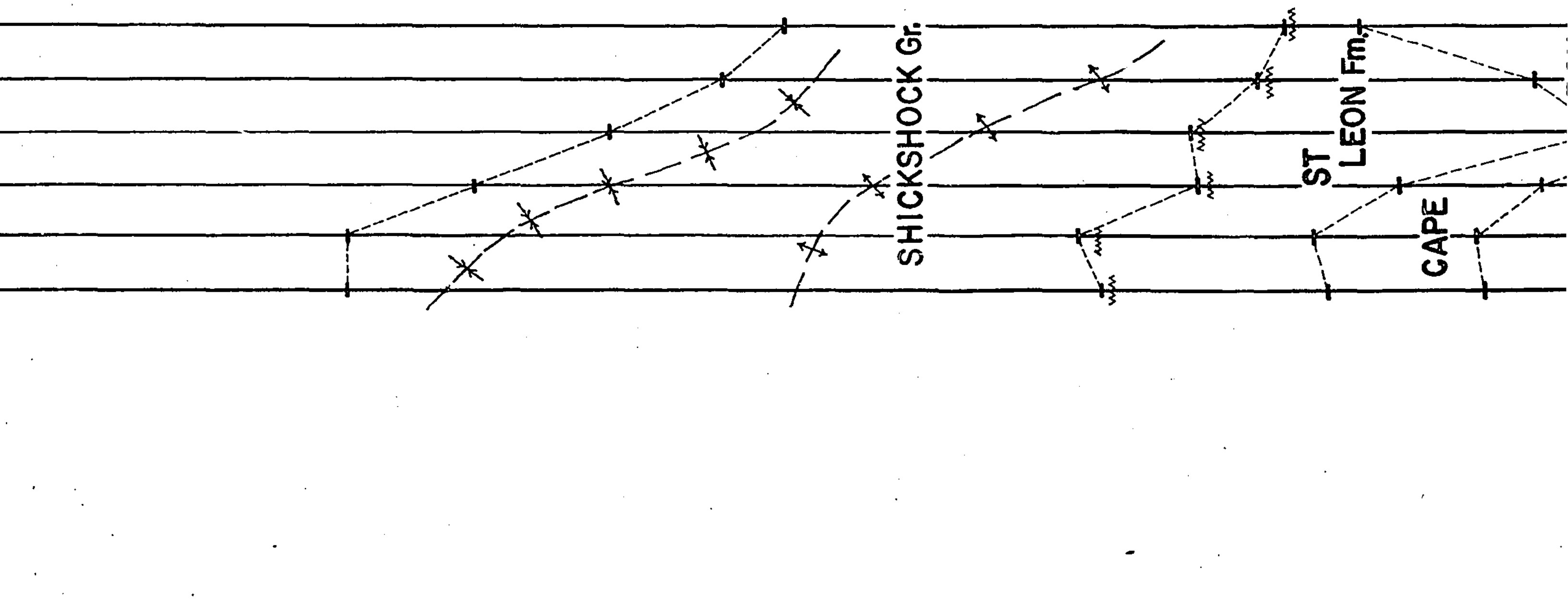


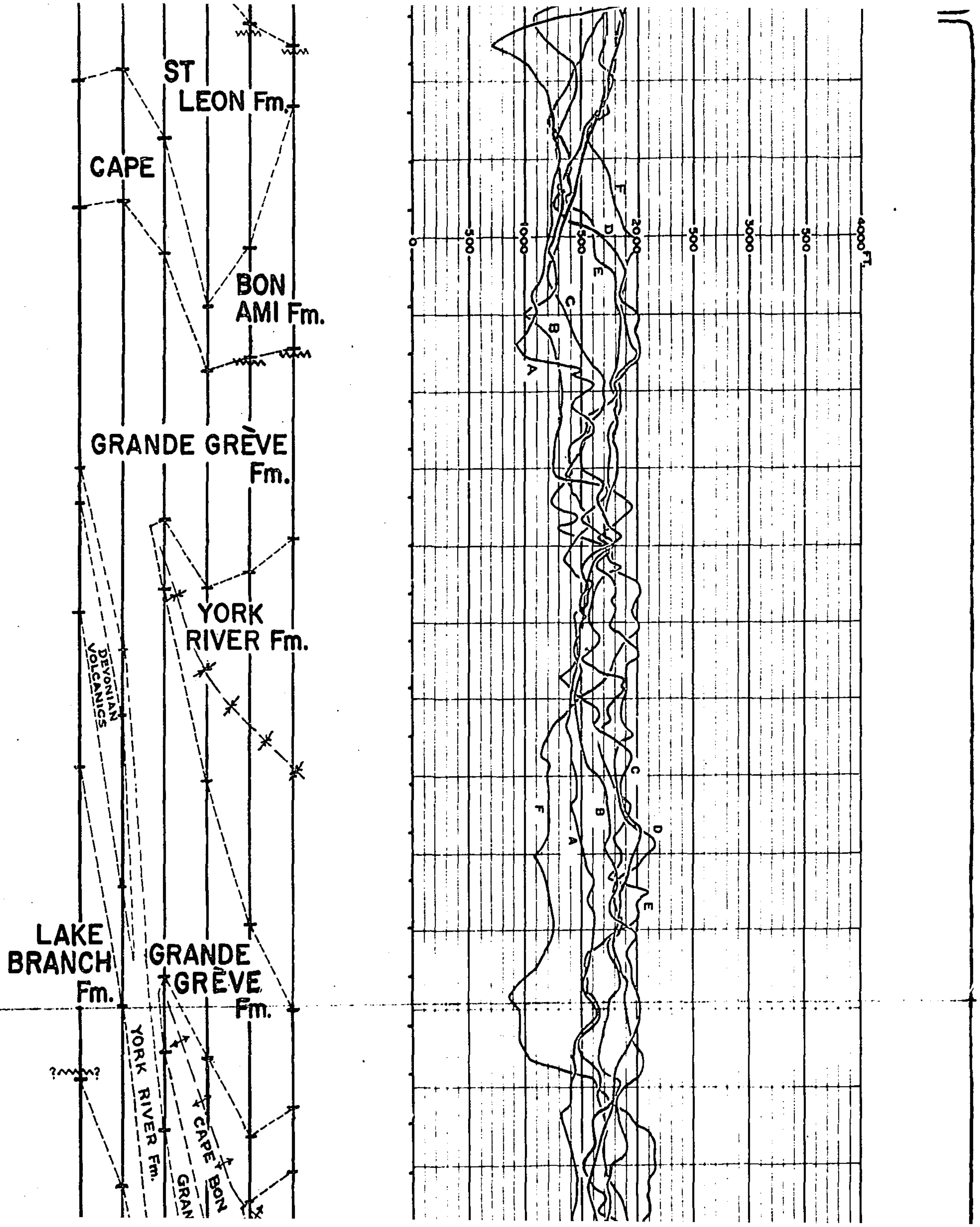
Note

The superimposed projected profiles were drawn for arbitrary 10-Km wide blocks of topography, chosen perpendicular to the structural trend (the 6 profiles represent a 60 Km zone with a length from Chaleur Bay to the St.Lawrence River). The profiles were drawn from 1:50,000 scale topographic maps of the N.T.S., by using a T-square and a right-triangle to obtain a running projection of the maximum altitudes along the length of a topographic strip.

NORTH-CENTRAL BELT



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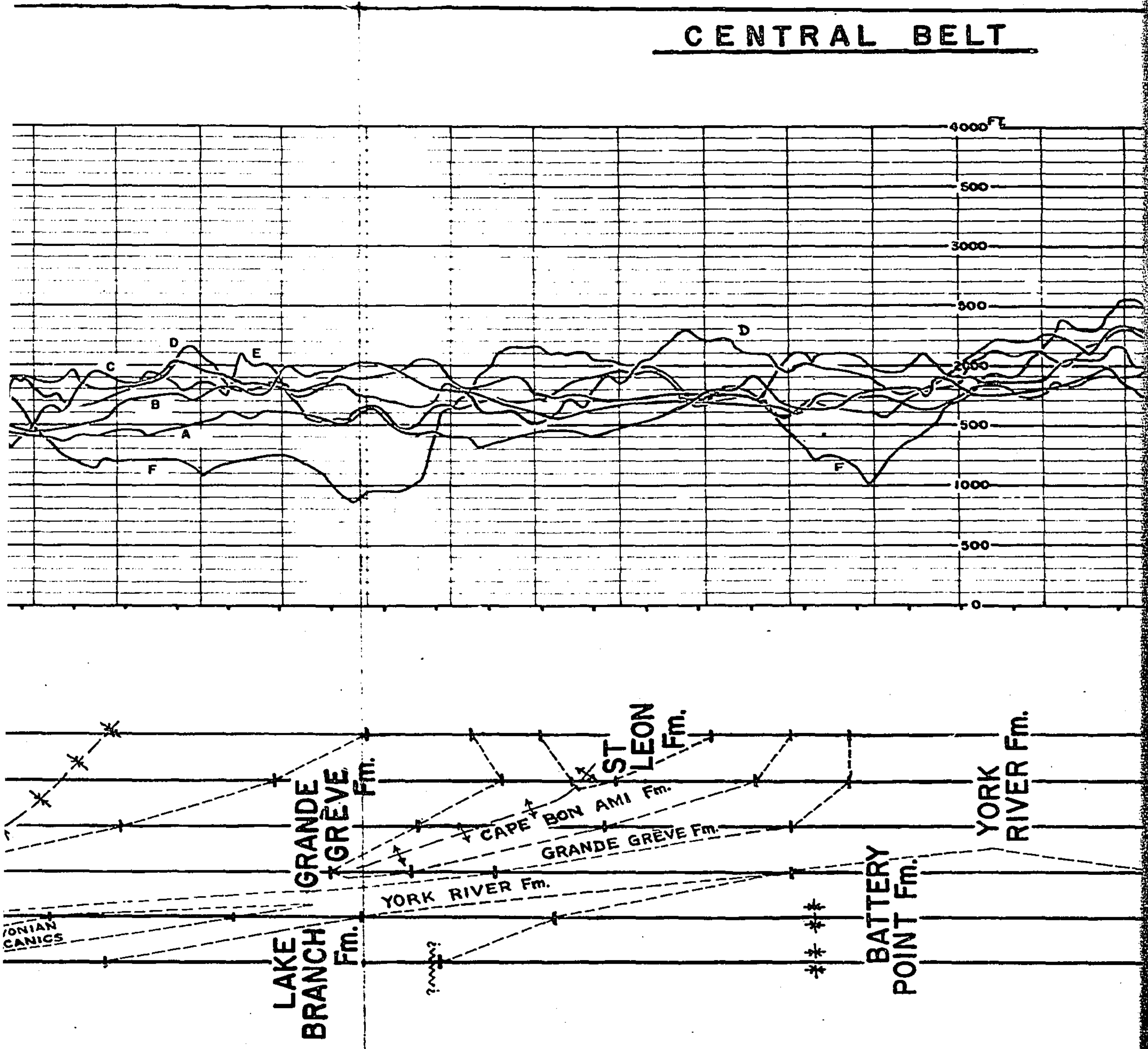
CENTRAL BELT
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YORK RIVER Fm.
BATTERY POINT Fm.
YORK RIVER Fm.
ONIAN
CANICS

2.3 General Physiography.

2.3-(1) Introduction.

The boundaries of physiographic regions of Gaspé may be generalized from the National Topographic Series map sheet 22SE-Gaspé-NW48/68, at 1:500,000 scale, with hypsometric tints. Three units can be outlined:

a) - an extensive plateau surface, deeply incised by rivers, present throughout the peninsula at an altitude of about 1500-2000 ft;

b) - a mountainous region, in the north-central part of the peninsula and as a belt extending to the west - the Shickshock Mountains - at an altitude ranging 2000-4160 ft;

c) - narrow belt of coastal lowlands, best developed in the southeastern Gaspé.

The western Gaspé landforms are well represented on the 1:50,000 scale topographic maps with 50 ft contours, from which the lithology-altitude sampling proceeds; they are included in the pocket at the back of the thesis.

2.3-(2) Geomorphic history.

The first general (and somewhat rambling) account of the physiography and glacial geology was published by Coleman (1922). Alcock (1926; 1935) mapped the Mont Albert quadrangle and the rocks around Chaleur Bay, and wrote on the physiography in detail. Alcock (1935, p. 109-126), on scant visual evidence and following Davis' (1889; 1899a; 1899b; 1902b; 1905b) popular peneplain theory, postulated a polyphase landscape system for the Gaspé, with remnants of two cycles preserved. He outlined the following geomorphic history:

a) - Continuous subaerial erosion since Devonian time;

b) - Development of the "Shickshock Peneplain" (named by Alcock, 1944, p. 16) - of probable Early Tertiary age and now represented by summits of Mont Albert, Tabletop, Mt. Lyall and the top of the Shickshock Range;

c) - Uplift of about 1,500 feet and the inauguration of a new cycle of erosion.

d) - Development of a second peneplain on the sedimentary rocks north and south of the Shickshock Range - the "Gaspé Peneplain" (named by Alcock, 1944, p. 16). Remnants of the older surface were preserved due to the resistance of the underlying rocks (granite, peridotite and tough metavolcanics). This upland is correlated by Alcock (1935, p. 114) with the "Atlantic Upland" of Nova Scotia, New Brunswick and Newfoundland.

e) - Further uplift, probably in the Late Pliocene, and the inauguration of the present erosion cycle.

f) - Minor modifications by local ice sheets and continental glaciation.

From the time of Colleman and Alcock, the interpretation of Gaspé landforms has followed strictly the Davisian approach. The appealing simplicity of a three-stage system of reference, paralleling human development: youth, maturity and old age; and the easy consideration of cyclical uplift and reduction to base level, followed by rejuvenation, have won it many followers. Russel (1958, p. 2) comments:

> "The concept of the erosion cycle accounted for a rush of peneplain hunters who were likely to regard anything from alleged accordance of summit levels to broad alluvial flats as evidence of a completed cycle. The quest eventually lost popularity, however, so that within recent years the rate of peneplain discovery has come to a near halt."

The inherent danger is that the system is simple to apply and results in considering landscape equally simple. Strahler (1950c) presents the following criticism:

> "Davis' treatment of....geomorphic subjects was completely qualitative. I do not recall having seen a measurement of slope angle or a precisely measured slope profile....Neither is there any penetrating analysis of erosional processes based on mechanics of fluids or plastic materials.... Davis' treatment appealed then, as it does now, to persons who have had little training in basic physical sciences, but who like scenery and outdoor life."

In Gaspé, some students primarily interested in stratigraphy and engaged in the mapping of areal geology, have felt a need to include in their reports a section on interpretative physiography. Rather than limit their discussion to general introductory remarks and description, they have uncritically applied the peneplain hypothesis as a proven theory of Gaspé landforms.

An exception is Ollerenshaw (1963), who has pointed out the apparent strong bedrock control of topography in Gaspé:

p. 333: "A comparison of the geological map of the Cuoq Langis area with the topographic map and the physiographic divisions.....reveals the strong influence of the bedrock on the topography. This geological control is apparent in both the general divisions and the detailed features within them."

p. 357: "Evidence of peneplanation in north-western Gaspé is not convincing and requires general, not local statistical study. Geological control in physiographic development has been profound, particularly in northwestern Gaspé."

A few more-or-less-statistical studies have been made of the accordance of summit heights: Mattinson (1958) and Ollerenshaw (1963) made comparative cumulative counts of summit altitudes for Mount Logan and Cuoq map areas, respectively; Mattinson (1958, p. 34) found only moderate accordance of summits at 1800-2200 feet and 2300-2900 feet; Ollerenshaw (1963, p. 337-338) obtained definite accordance at several levels, which he considered to be topographic subdivisions controlled by lithology.

Mattinson (1958) constructed projected profiles for the Shickshock Mountains in the Mount Logan map area, and found the results inconclusive.

Lesperance (1960) applied the method of projected profiles extensively, in the Lake Temiscouata region, situated directly west of the thesis area, and found no evidence for postulating a peneplain.

In view of the fact that detailed study of the applicability of the peneplain hypothesis to Gaspé landforms has not been undertaken and since studies presented by people more concerned with areal mapping are to date, inconclusive, it is suggested that the term peneplain be dropped from future descriptions of Gaspé physiography and the terms Gaspé upland and Gaspé plateau be used.

Alternately, the development of Gaspé landforms can be considered within the philosophic framework expounded by Strahler (1952), Hack (1960) and Chorley (1962). The landscape may be appraised as an open system (von Bertalanffy, 1950) in dynamic equilibrium or in a steady state condition, in which there is a constant adjustment of the internal form-variables to the external conditions imposed largely by climate. Energy within the system is equated to the relative elevation of particles of water and sediment (Leopold and Langbein, 1962), and all topographic elements are considered to be eroding vertically, at approximately equal rates. Thus, there is little areal rearrangement of topography, but a constant readjustment of system parameters such as stream gradients, drainage patterns and density, and valley-side slopes, etc., all of which are mutually interdependent.

Howard (1965) presents a general review of the equilibrium concept and Schumm and Lichty (1965) have examined the theory with respect to time span. Curry (1964) has written a short general comment.

2.3-(3) Qualitative estimate of lithologic control.

A diagram of superimposed projected profiles was drawn for western Gaspé (method outlined in Dury, 1960, p. 170), and correlated with lithology (figure 3, p. 23-foldout). The profiles were oriented perpendicular to the structural trend and represent 10-Kilometer wide, adjacent belts of topography. They were drawn, not to test the accordance of summit heights, but to provide a preliminary overall view of the maximum altitudes supported by the various geologic formations.

A definite correlation between lithology and altitude is apparent and there is a more-or-less consistent relationship in the relative position of the rock units. Within the central belt, the Battery Point greywacke sandstones, the York River feldspathic sandstones and the Grande Grève siltstones and siliceous limestones support the highest altitudes, in approximately decreasing order; the Cape Bon Ami argillaceous to silty limestones, the St.Leon calcareous siltstones and the Lake Branch poorly-consolidated redbeds support lower altitudes; over the Fortin Group, landform and bedrock are in extremely close adjustment - profiles representing a 60-Mile wide zone , with a length of over 7 miles, show a relief of only 200-300 feet. The Quebec Group rocks, mainly shales and slates, support altitudes just above the range of the Lake Branch redbeds. In the southern belt, the Honorat Group sandstones and mudstones stand uniformly highest, with the Restigouche Group sedimentaries and basic volcanics and the Matapedia Group limestones at lower levels. Profiles for the Matapedia Group zone show a relief of only 150-200 feet.

Some structural control is apparent within the central belt; synclinal areas are found generally lower than anticlinal areas and faults show good correspondence to scarps.

Analysis of the development of river systems in western Gaspé has been attempted by Alcock (1926, p. 16-23) and Ollerenshaw (1963, p. 341-348). A diagram of the principal drainage lines is included in this report (figure 4, p. 29). An excellent example of piracy controlled by differences in bedrock lithology is available from the Big Berry Mountains West map-area: the capture of the headwaters of Square Forks River (traversing the resistant Battery Point greywacke sandstones) effected by Lake Branch Brook (which is underlain by the Lake Branch redbeds). Downcutting through the poorly consolidated redbeds took place much more rapidly, with the result of strong headward erosion by tributaries and finally, breaching of the watershed and capture. It is possible that glacial action may have speeded up the process and contributed in some measure to the final breaching.

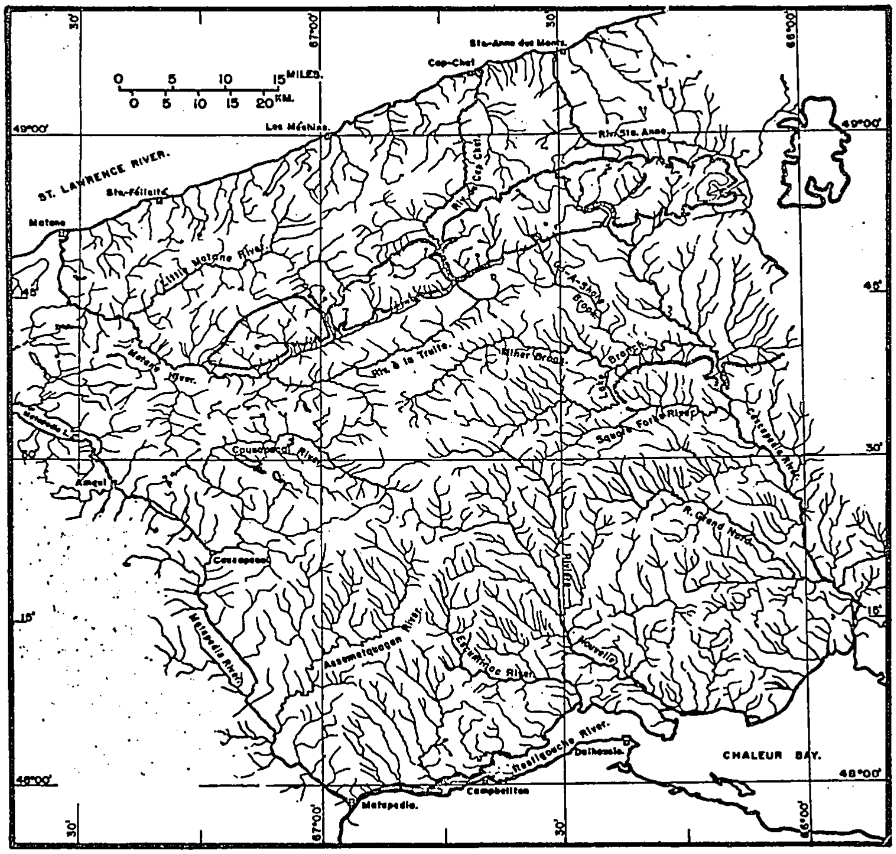

Figure 4.— Drainage pattern of western Gaspé sketched from Canadian Topographic System 1:250,000 series maps 22A, 22B, 22G, 22H, and reduced to scale shown.

A qualitative estimate of lithologic control within the Quoq map area is provided by Ollerenshaw (1963, p. 333-334):

> "Examination of the upland region reveals that the numerous quite deeply incised valleys of the northwest are developed on St. Lawrence Complex shales. The flatter, less deeply incised central, south-central and Trout River areas, are developed over moderately inclined, more uniform Silurian and Cape Bon Ami strata....The elevated plateau region of the southeast is based on the more resistant Grande Grève and York River formations (with the latter tending to have a more even surface than the former). The Grande Grève siltstones appear to be the most resistant lithology of the upland in these parts and also form the highest ground in the Causapscal area to the south."

2.3-(4) Glaciation.

Coleman (1920; 1921; 1922) and Alcock (1928) first stated the belief that the Labrador ice sheets were not able to overtop the high rim of the Shickshock Mountains and the Tabletop block; and that the interior of Gaspé, thus did not suffer continental glaciation. Subsequent studies by Alcock (1935; 1944), by Flint, Demorest, and Washburn (1942), by Carbonneau (1949), and by McGerrigle (1952), favor complete glaciation, but with very little resultant erosion. The evidence of Shield erratics found on the upper slopes and summits of the Shickshocks and Mont Albert is not conclusive, but in view of the fact that much higher peaks of the White Mountains Range, situated further south, were glaciated, the hypothesis of complete overtopping of the Shickshocks by Labrador ice seems tenable. Flint (1957, p. 82), in his textbook on Glacial and Pleistocene geology, writes:

> "A conspicuous example of slight glacial erosion throughout a wide area is the region extending from the crest of the Shickshock Mountains, the backbone of the Gaspé Peninsula, southward across Chaleur Bay through western New Brunswick. In this region of about 15,000 sq mi, glacial erosion is so slight that the terrain has been considered by more than one geologist to have escaped glaciation."

2.4 Climate and processes of denudation.

The brief discussion given below is valid for only the present climatic regime. The paleoclimate under which the Gaspé landforms developed may have been much different.

Weather records for the Gaspé Peninsula and the immediate surroundings are available from more than thirty stations[1] (recorded from 1883 at Cap Chat and at Cap Madeleine; from 1913 at Causapscal; from 1932 at Price; and from 1933 at Mont Louis). The mean annual rainfall is of the order of 20 inches and about 10 feet of snow. The mean annual temperature is about 35°F.

Under these conditions, the most effective processes of denudation may be expected to be, in order of decreasing importance: dominant mechanical weathering, erosion by running water, processes of mass wasting, and some chemical weathering (Leopold, Wolman, and Miller, 1964, p. 40-46).

The present climatic regime provides daily, rapid fluctuations of temperature, which coupled with high relief, provide an ideal setting for mantle creep; and when frictional and cohesive stresses between bedrock and mantle are exceeded, the initiation of debris avalanches. Creep is seen to be an important process, from the position of trees growing on slopes. The vector of curving trunk growth is found to point downslope in increasing number of cases, as the slope angle increases. Debris avalanches have been described by Mattinson (1964, p. 12, and Plates IV, V) under the term "mudflows" and by Ollerenshaw (1963, p. 338-340) as "landslips".

Frost shattering of bedrock is found commonly throughout the Gaspé. On higher slopes (Mount Richardson, etc.), extensive areas of felsenmeer occur.

Soil development is minimal, due to the steep slopes and high rate of activity on them. In the south, where temperatures are higher and chemical weathering more important, some fairly good soil profiles are found; for example developed on the flat interfluves underlain by Matapedia Group limestones.

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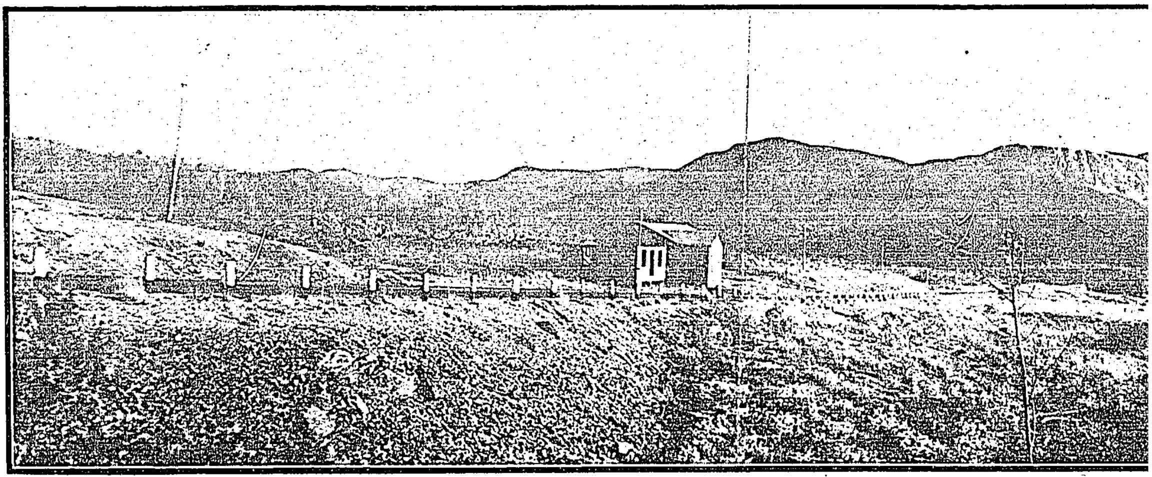
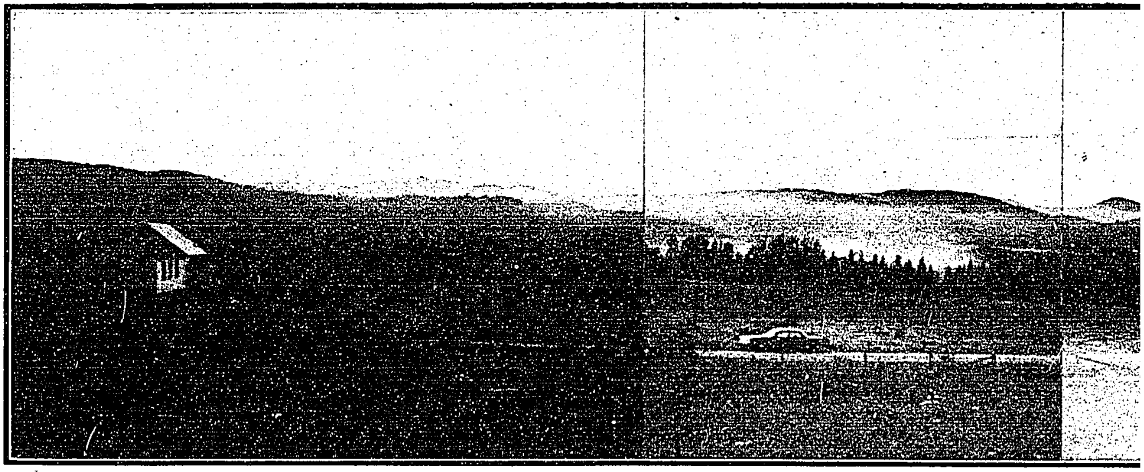
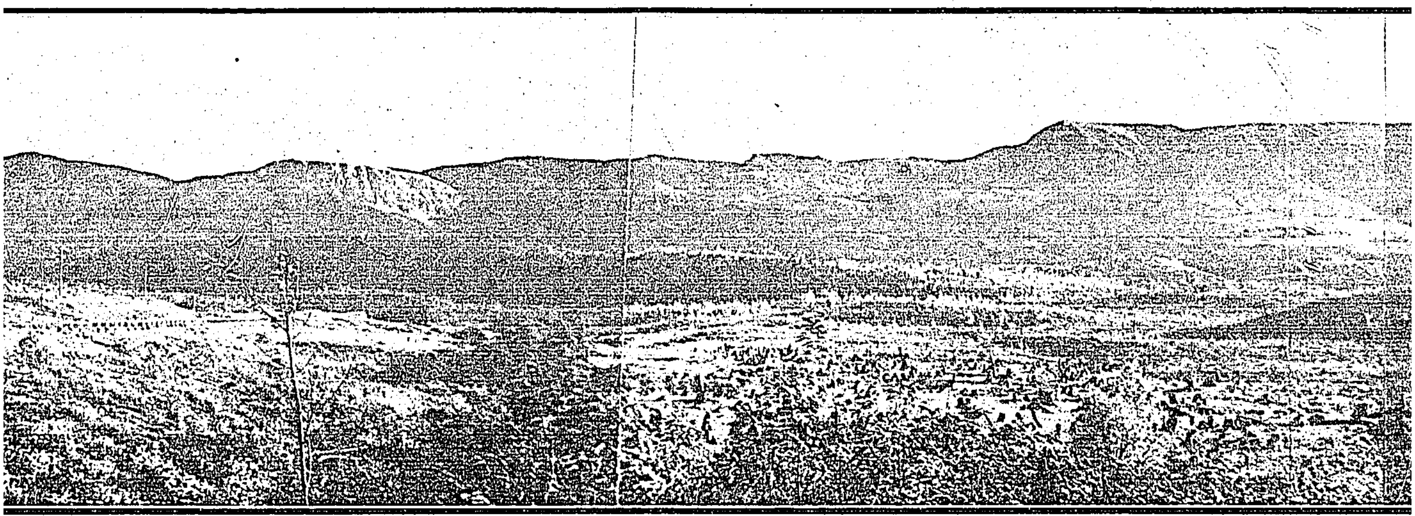
[1] – Available from the Department of Transport, Meteorological Branch, Toronto, Ontario.





Photographs by Author.



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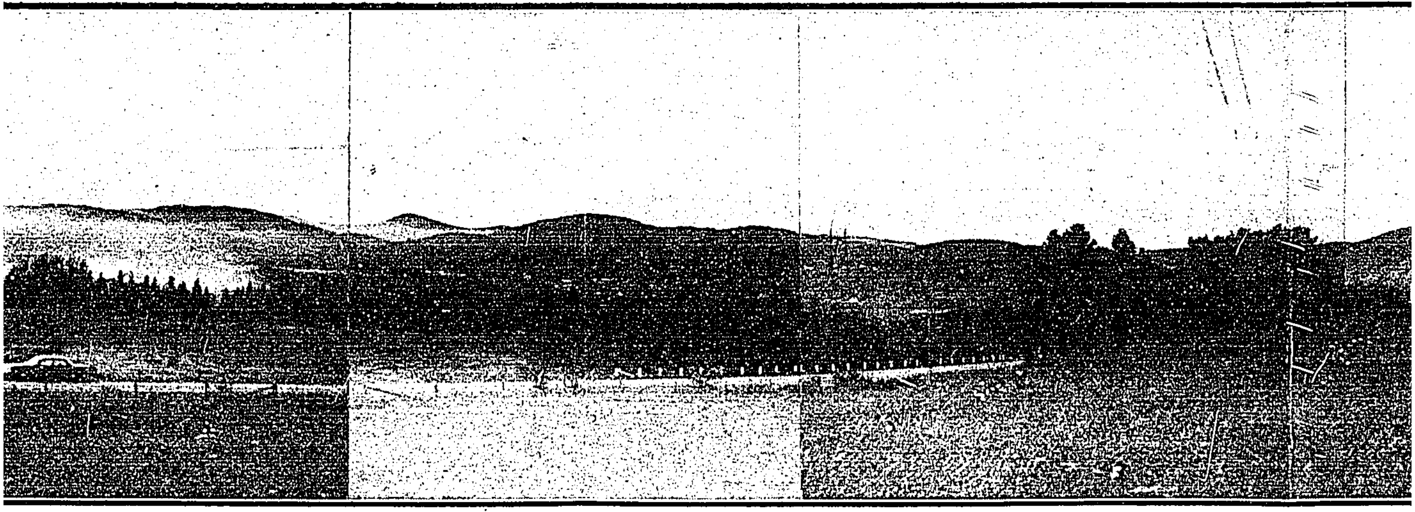

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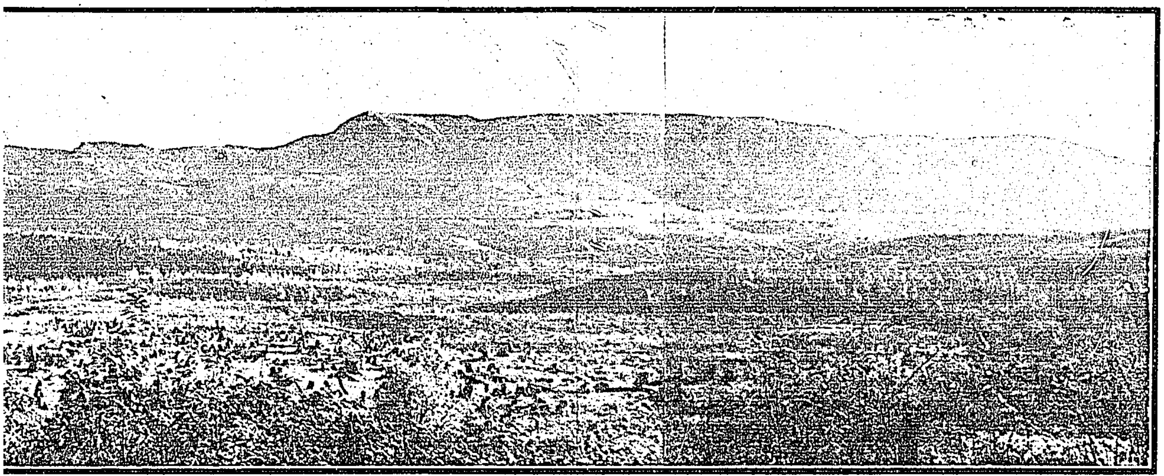
PLATE - A



View of the north-front of the Shickshock Mountains.

The foreground is the flat upland underlain by Québec group rocks.
- vicinity of Gaspé Park north gate (Ste Anne).

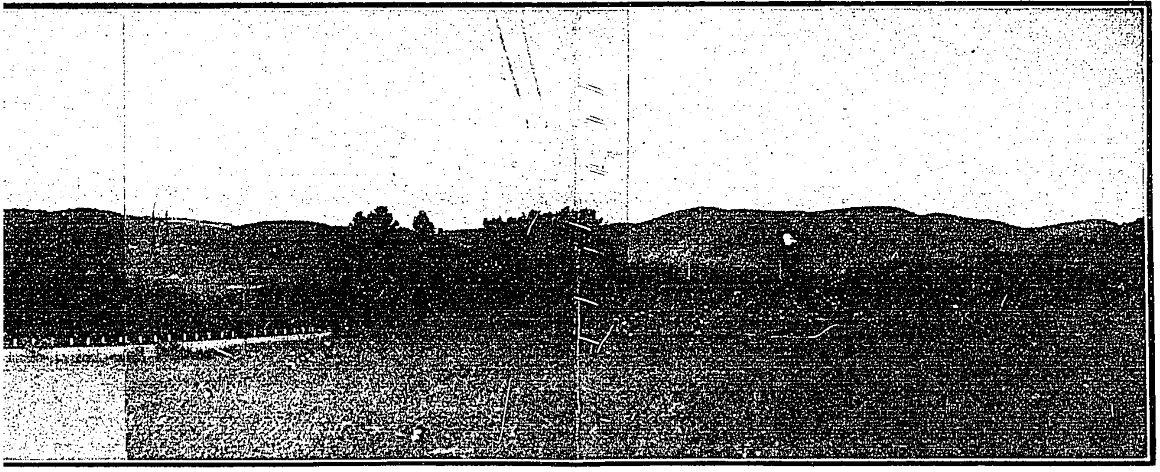
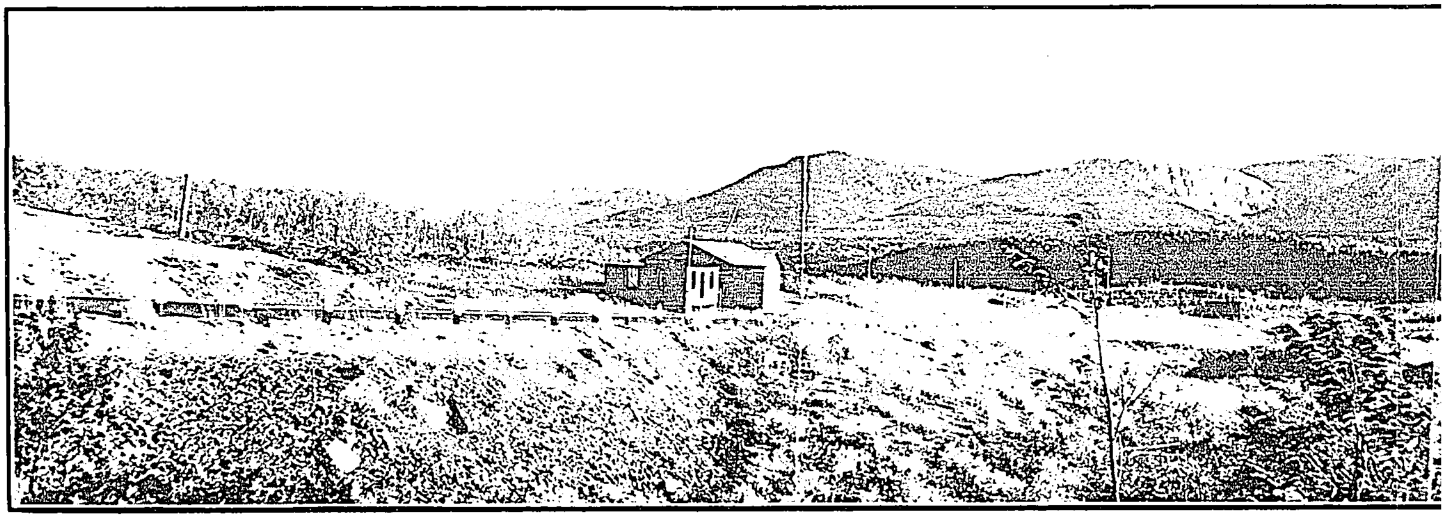


PLATE - B

View of rolling topography underlain by Honorat gr rocks.
- vicinity of Cascapedia River; looking west.



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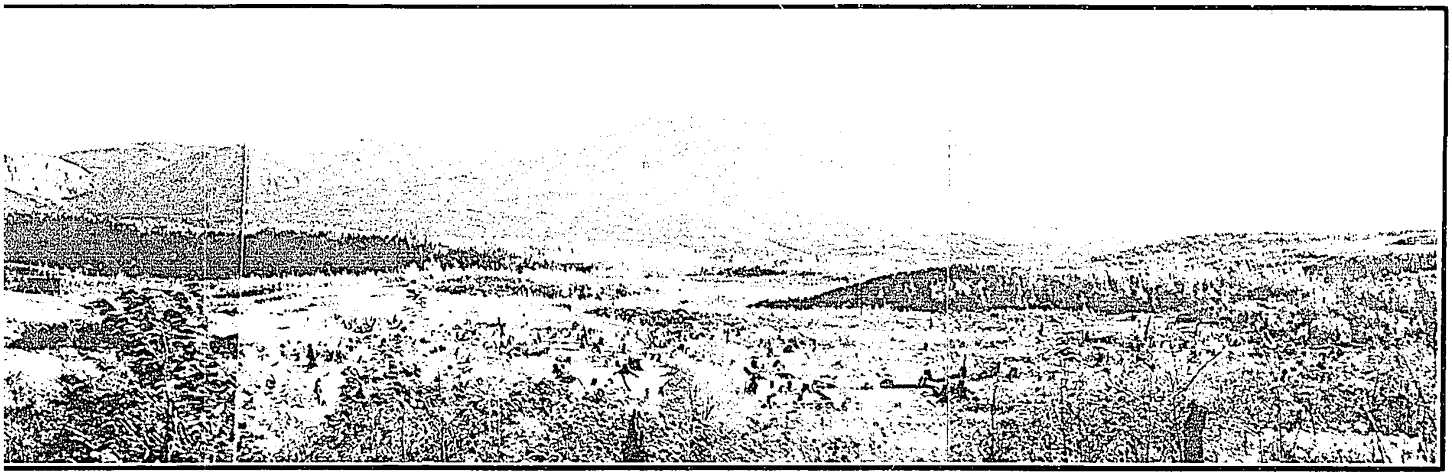


View of the north-front of the Shickshock Mountains.

The foreground is the flat upland underlain by Québec group rocks.
- vicinity of Gaspé Park north gate (Ste Anne).

PLATE - B

View of rolling topography underlain by Honorat gr rocks.
- vicinity of Cascapedia River; looking west.

CHAPTER III.

LITHOLOGY and ALTITUDE ANALYSIS

3.1 Problems of data input.

It is proposed to analyze a bivariate landform system comprised of the independent variable, bedrock, and the assumed dependent variable, topographic altitude. The model supposes that within a humid temperate region, lithology controls the form and altitudinal position of landscape.

Two input factors limit the analysis: a)- the scale, precision and availability of topographic mapping, for topography cannot be analyzed quantitatively over any appreciable area, except through the medium of prepared planimetric maps; and b)- precision and availability of geological mapping at a corresponding scale and for corresponding areas.

Figure 5, p. 34, provides an index of the available topographic mapping for western Gaspé; table 2, on the same page, lists the maps used. Not all the maps are equally precise and accurate - two sheets, the Causapscal and Cuoq areas, are at present under consideration for revision. A.C.Tuttle, (personal communication, 1965) states that the above maps were compiled from parallax measurements based on ground barometric elevations with contouring hand-sketched on photos and transferred to the manuscripts, so that "...in effect the contouring shows relief shapes and cannot be relied on too greatly for absolute elevations." Most of the maps of central and western Gaspé were compiled by multiplex plotters, based on altimetric heighting using helicopters, and it is considered that "...these values are more reliable than the heighting obtained from ground traverses but at that time, the methods being used were in experimental stages and considerable adjustments were necessary in photogrammetric bridging".

The general standards are that 90% of the contouring should fall within one half the contour interval of its correct position, and any spot height read from the map should be accurate to within one-half the contour interval.

With the possible exception of the Cuoq and Causapscal maps, all the topographic sheets are considered to be within the required accuracy standards.

The available geological mapping is not all of the same uniform standard. Some areas of western Gaspé have been mapped under the auspices of the Québec Department of Mines (Natural Resources); some have been covered within the framework of Ph.D. theses problems; and some studies have been made by geologists of the Geological Survey of Canada. The greater number of studies have been published by the Québec Dept. Mines, either as "Geological Reports", which are fairly comprehensive and which have a geological map on a topographic base, with contours; or as "Preliminary Reports", which are brief statements, designed for quick reference, and which feature a geological map, without any contour data.

Of the eight map areas studied, three (Mount Logan sheet, Big Berry Mountains sheet, and the Cuoq sheet) were mapped as Ph.D. studies; two are covered by preliminary reports, with detailed geological reports pending (Oak Bay area and Causapscal East sheet); and two areas are covered by unpublished "Interim Reports" (Rivière Angers East sheet and the Escuminac map area). The Mont Albert-Tabletop area is covered by a thesis study and a Geological Survey Memoir. Another Geological Survey Memoir covers parts of the southern area of the Peninsula (Alcock, 1935).

3.2 Procedure.

Topographic map sheets at a scale of 1:50,000 and geologic maps at a scale of 1:63,360 (1 inch to 1 mile) were compared and eight map-areas were found to have coverage by both.

Geological boundaries were transferred onto the topographic map sheets; and these were used as the basis for the study. Table 2 and figure 5, on page 34, list the maps, which were photoreproduced and copies of which are included with the thesis, in the pocket at the back.

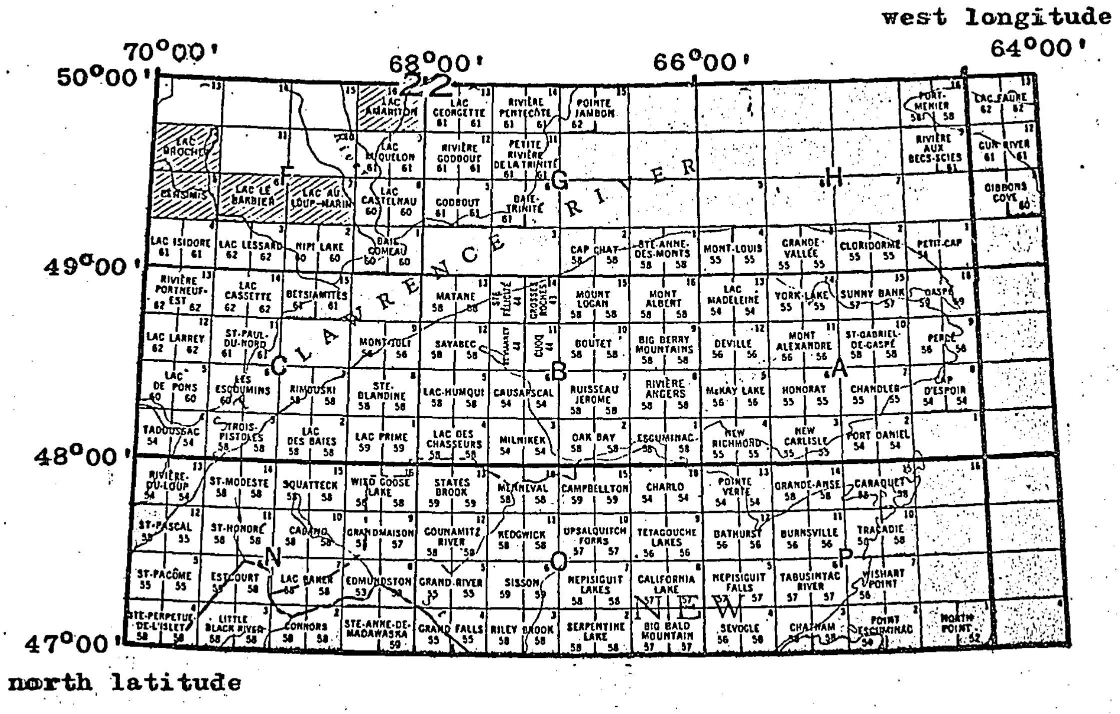


Figure 5.— Available topographic map coverage of the Gaspé region, by Canadian National Topographic System 1:50,000 series sheets. Maps used are listed below.

Table 2.— Topographic map sheets used in this study.

MAP SHEET		N.T.S. DESIGNATION	ISSUED
MAP (1)	Mount Logan sheet	22-B-15	1958
MAP (2)	part of Mount Albert and Lac Madeleine sheets	22-B-16-East 22-A-13-West	1958 1954
MAP (3)	Big Berry Mountains sheet	22-B-9-West	1958
MAP (4)	Rivière Angers sheet	22-B-8-East	1958
MAP (5)	Escuminac sheet	22-B-1	1958
MAP (6)	Oak Bay sheet	22-B-2	1958
MAP (7)	Causapscal sheet	22-B-6-East	1954
MAP (8)	Cuoq sheet	22-B-11-East	1944

3.2-(1) Theoretical basis.

The theoretical framework of sampling of the lithology-altitude relationship is governed by the following assumptions:

1)- Subaerial topography, by definition, has altitudinal position (above a mean sea level), and may be considered as made up of an infinite population of altitudes. The population is arranged in a spatial distribution that is both orderly and integrated and in accordance with some complex set of natural laws.

2)- For a stable cratonic block, which has had a lengthy and continuous subaerial exposure, the arrangement of altitudes at any given instant in time is the product of the interaction of two variables: a) the predetermined erosional resistance[1] of surface crustal material (bedrock), and b) the cumulative effect of all past processes of denudation[2], acting to reduce the landmass.

Since process depends on climate (Leopold, Wolman and Miller, 1964, p. 40-46), then for areas of similar climatic environment, processes of denudation should be of approximately equal magnitude and rate, and only the lithologic variations should be manifest in the position and distribution of the altitude population. In fact, lithologic units may then be expected to support separate characteristic populations of their own.

3)- Erosional resistance is fundamentally determined by the minor units of lithologic similarity (the strata) and their arrangement in space. Major units of lithology (the formation and group), however, provide a better assimilation of the effects of process and allow lithology to be capable of meaningful analysis.

1, 2 - Erosional resistance is defined to include the physical and chemical properties of the rock, the attitude of the strata and the minor structural features, schistosity, cleavage and jointing; process is considered to also include the effect of vegetal cover.

4)- The initial variable altitudinal position of the landmass is of minor importance. An equilibrium state is first reached and the topography is then reduced through downwasting at a constant rate, according to the erosional resistance of each lithologically similar component-area.

5)- Extending the previous assumption, topography is viewed as an interrelated "jig-saw puzzle", with interlocking lithologic units approximating to the "puzzle pieces". The lithology-altitude system may be expected then, to have an inherent indeterminacy, or, after Leopold and Langbein (1963, p. 191), to exhibit a "....variability which may be expected as a result of incomplete dynamic determinacy."

3.2-(2) Sampling.

The altitude sampling of rock units described in chapter-II proceeds according to the precepts listed above. Since the populations are theoretically infinite in size, representative samples of convenient but meaningful numbers of variables, must be drawn. According to the first postulate, we are required to sample not only the absolute altitude values, but also the areal arrangement. Thus the sampling must be both random and systematic. We could not, for instance, use the method of random co-ordinates (Strahler, 1954, p. 3; Krumbein and Miller, 1953). The only suitable arrangement is to use a randomly-oriented grid system, which provides a series of systematic grid intersections at which altitudes may be counted.

The grid mesh size value is of particular significance, for it governs the validity of the prefigurement of the population, by the sample. If the grid mesh is too small, the time required to complete the study may be impracticably long; if it is too large, the sample may not be representative of the population. A key is the horizontal spacing of topographic contours. By drawing lines at random, say 20 cm long, and counting the number of contours crossing and then dividing the length by the number of contours, an empirical value is arrived at on which to base the optimum grid mesh size. For example, measurements for the Honorat Group in the Escuminac map-area yielded an average value of o.23 cm. (6 measurements); for the Matapedia Group, in the Oak Bay area, a value of 0.20 cm was found (6 measurements).

For this study, the consideration of a theoretical grid mesh size was overshadowed by the advantages of using an available ready-made system. Canadian National Topographic Series maps can be obtained with a grid system printed on (Transverse Mercator Projection); the mesh for 1:50,000 scale maps is equal to 1 Km. The grid is"random"; and by adopting it, considerable labor was saved in drafting. The accuracy of machine-plotting is an added feature. The grid was halved, resulting in a final mesh of 0.5 Km (1 cm on 1:50,00 scale maps).

The testing of the lithology-altitude relationship proceeds from the geologic-topographic maps with overall o.5 Km grid, by the counting of altitudes at each grid line intersection point and grouping according to lithology. The sampling follows class limits equal to the contour interval, and altitudes measured from the contours were grouped into classes of 0-49 ft, 50-99 ft, and so on. For the Cuoq (preliminary map) sheet, 100 ft contours are available and the counting proceeded in 0-99 ft, 100-199 ft classes. When a grid intersection point lay on a boundary line, the altitude value was included in both formation counts; when a point was located within the areal boundary of a lake or major river, the altitude value was taken to be one contour interval lower than the contour enclosing the body of water; and in the case of rivers, the nearest contour was taken.

Frequency distributions of altitudes were developed for 25 different lithologies and 55 separate areas; individual counts ranged from 26 to 2350 grid points; a total of over 18,000 points were counted.

To insure the accuracy of the grid point counts against significantly large operator error, the altitudes of at least two sample-units of each of the map areas, were counted twice. If the second count availed an appreciably different structure of frequencies, then a third counting was initiated, and the three were averaged. Since the orientation of the grid was not changed, these counts are not separate samples, and no analysis of sample variance can be considered. In the Rivière Angers and Oak Bay map-areas, all the sample-units were counted twice, while for the Québec Group (Mount Logan map-area), with 2350 grid intersections, only a single counting was attempted.

The counting of altitude values is a tedious and time consuming task, and requires a constant alertness on the part of the operator. The writer tried in vain to enlist undergraduate assistants and consequently, all the altitude counts which appear, were made by the author alone.

Time did not permit it, but a suggestion for future work would be to shift the grid system a distance equal to one half the diagonal length of the grid square, and proceed to count another sample. This can be done by simply observing the altitude values at the centre of each of grid squares, as they now stand. This second sample can be used to provide two types of information about the sampling. It can be treated as a second and separate sample from the population; or when added to the frequency distribution obtained in the first sample, provided in this report, it gives a sampling density twice that of the present study - i.e., it is then equal to a sample taken with a grid mesh size of 0.25 Km.

3.2-(3) Grouping and presentation of sample data.

A vast body of data is unmanageable unless it is grouped according to some form of order. Grouping enables an overall visual appraisal and the making of comparisons and decisions as to further testing or analysis.

The data of sample frequency-distributions of altitude can be arranged in several ways:

a) They can be tabulated on a common base of the altitude values of class limits. This allows a comparison of the sample range of altitudes and the frequency maxima. Relative-frequencies can be calculated by dividing the frequencies of classes by the total frequency of the sample; these values can then be tabulated also. All the data was tabulated according to the above method and is included as Appendix-A.

b) Graphs may be plotted on arithmetic co-ordinate paper, with altitude as abscissa and class frequencies (or percent class frequencies) as ordinate. If mid-points of classes are used and joined, the resulting figure is a frequency-polygon; if the frequency values are represented by vertical rectangles of width equal to the class interval, the graph is termed a histogram. Relative-frequency histograms are constructed by plotting percent-frequencies. For all sample distributions, histograms were plotted and are included as Appendix-B.

c) Cumulative-percent-frequency curves are obtained when the percent-frequencies are cumulated, to read as greater-than or less-than altitude values, and are plotted against altitude. The altitude values chosen for plotting should be either the lower or upper values of class limits, or the center value of class limits. Cumulative curves were plotted for all sample distributions and are included as Appendix-C. The plotting is on probability paper, with arithmetic abscissa and probability ordinate (a Gaussian curve of probability theory plots as a straight line. This allows a comparison with the Gaussian "normal" frequency distribution curve.

The histogram is the most readily understood presentation of frequency distribution data and probably yields the greatest amount of readily digested facts. Distributions however, cannot be effectively compared unless numerical parameters are available.

3.3 Analysis and calculations for frequency distribution parameters.

3.3-(1) Frequency distribution analysis.

Sampled frequency distributions can be subjected to exact mathematical specifications. By use of statistical theory, parameters can be computed which describe the peculiarities of a distribution and which, in effect, solve it.

The methods of statistical analysis have been available for a relatively long time (since the 1800's); they were first formally introduced to workers in geomorphology by Strahler (1950a; 1950b; 1954). For geologists in general, two textbooks are available: Miller and Kahn (1962) and Krumbein and Graybill (1965). Gregory (1963) has introduced statistical theory for geographers (with some applications to geomorphology). Frequency distribution analysis theory is given in the above texts and is also available from countless others. Arkin and Colton (1957) provide a general listing; many recent books have appeared in the subject. The discussion which is presented on the pages to follow is taken from Dixon and Massey (1957), Spiegel (1961) and Parrat (1961). It is not planned to undertake a rigorous statistical treatment of the data but rather to describe in detail the meaning and interrelationships of distribution parameters and to correlate this with topography.

Frequency distributions of all types of data have certain characteristics which can be mathematically defined and by which the distributions can be summarized and compared. These common properties are:

a) central tendency
b) dispersion
c) symmetry.

These properties can be readily visualized by inspection of a histogram plot (Appendix-B).

3.3-(2) Measures of central tendency.

Several location indices or average values can be computed for a distribution. These lie centrally within a set of data and are thus known as measures of "central tendency". The most common are:

a) The arithmetic mean ($\bar{X}$)
b) The median (Md)
c) The mode (Mode)
d) The geometric mean (Gm)

a) The arithmetic mean:

This parameter is the most commonly used and generally understood average. It is a measure of the center of mass of a distribution and is equal to the sum of the values of the distribution divided by the total number of observations. It is computed from the formula:

$$\bar{X} = \frac{\Sigma fx}{N} = \frac{\Sigma(f \cdot MP)}{N}$$

where: $\bar{X}$ = arithmetic mean of sample
f = frequency of altitude class
x = altitude of class interval
N = total number of observations
MP = mid point of class interval
Σ = summation

The arithmetic mean has the advantages that its computation is relatively simple and that its value may be treated algebraically (the arithmetic means of several subgroups can in turn be averaged). Disadvantages are that extreme values produce a "distortion".

b) The <u>median</u>:

The median is defined as the middle item when the items are arranged according to size (Arkin and Colton, 1957, p. 19). The median "is an average of position while the arithmetic mean is a calculated average." It is equal to that value of the variable such that half of the members of the distribution are larger and half are smaller. First, the position of the variable is determined from $(\frac{N}{2})$, and then its value is computed by interpolation from:

$$Md = L_{mc} + \frac{i}{f} \cdot C$$

where: Md = median

L_{mc} = lower limit of class interval the median falls in

i = number of items needed within the frequency group the median falls in

f = frequency of the group the median falls in

C = value of the class interval

The median is easily calculated and is independent of unusual values. Thus it is a good measure of central tendency of a series. A disadvantage is that it may not be treated algebraically (the median of a series of median values of samples drawn from the same population, cannot be computed). Its significance in this study appears at first glance to be very small.

c) The <u>mode</u>:

The mode cannot be calculated exactly, but may be approximated from:

$$Mode = L_{mo} + \frac{f_a}{f_a + f_b} \cdot C$$

where: L_{mo} = lower limit of modal group

f_a = frequency of class interval above modal group

f_b = frequency of class interval below modal group

C = value of the class interval

The mode is the most frequently occurring value or the most probable value of a distribution. There may be only one principal tendency for modal aggregation of values or several. A polymodal frequency-distribution represents either a mixture of samples from several separate populations, or it may simply mean that the total number of observations is not sufficient to yield a smooth distribution. When the sample is very small, the modal value may be indeterminate - thus, the mode is dependent directly on the sample size. When the distribution is very irregular, the calculation of the mode is facilitated by doubling the class interval and combining the corresponding frequencies.

The mode is entirely independent of extreme items and is the most typical descriptive average. It has the advantage of being capable of approximation by observation, from either tabulated data or a histogram.

d) The <u>geometric mean</u>:

The geometric mean of a set of observations of 'n' numbers is equal to the n^{th} root of the product of their values:

$$G = \sqrt[n]{x_1 \cdot x_2 \cdot x_3 \cdot x_4 \cdot \dots x_n}$$

and by using logarithms: $$G = \text{antilog} \frac{\Sigma f \cdot \log(MP)}{N}$$

where: G = geometric mean
(and other symbols are as defined previously)

The geometric mean has the property of giving equivalent weight to proportional changes. It is less affected by values of extreme items than is the arithmetic mean, but has an inherent disadvantage in that calculations cannot be made where one of the frequency values is zero.

Of the four measures of central tendency, at first glance, the <u>arithmetic mean</u> and the <u>mode</u> appear to have the most ready applications in this study; the former is an average of the distribution viewed as a whole, and the latter describes form-elements within parts of the distribution.

3.3-(3) Measures of dispersion.

The measure of the spread of values about the central location is important for it reflects on the validity of the average. If the scatter of values is very large, the central value may not be very typical. Figure 6, p.45, illustrates this.

a) The range:

The range is the simplest index of dispersion and is equal to the absolute difference between the largest and smallest items of the distribution. Because of its dependence on only two items, it can be greatly affected by an unusual occurrence and it is thus, not a very efficient measure. The range is used when there are only a few values, the total number of which should also be given.

b) The standard deviation:

The standard deviation is a better index of dispersion and has found the most common usage. It is defined as the root mean square of the deviations about the arithmetic mean, and is computed from the formula:

$$S = \sqrt{\frac{\Sigma f \cdot (X-\overline{X})^2}{N}}$$

where: S = sample standard deviation.
(and other symbols are as defined previously)

The standard deviation provides a numerical guess as to the range of values into which the next measurement may fall. It depends on the value of every item in the distribution. It may be treated algebraically.

The square of the standard deviation (S^2) is known as the variance and it may be used as a measure of dispersion.

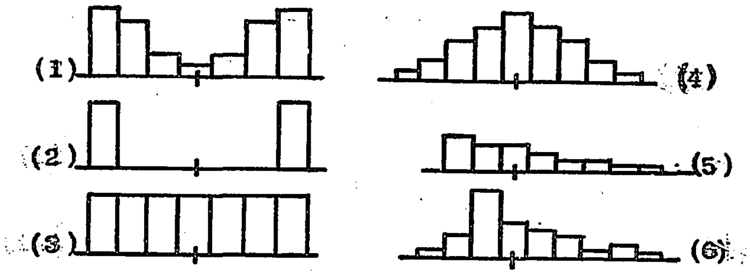


Figure 6 - Hypothetical frequency-distributions with equal arithmetic means, but different dispersion characteristics. (after Dixon & Massey, 1957)

c) The <u>mean deviation</u>:

The mean deviation is the absolute value of the sum of deviations about either the arithmetic mean or the median. It is calculated from the formula:

$$M.D. = \frac{\sum f \cdot |X - \bar{X}|}{N}$$

where $|X - \bar{X}|$ = absolute value of the deviation of sample values about the arithmetic mean.

d) <u>Relative dispersion</u>:

A measure of dispersion should be compared with the size of the average about which it is measured. For example, an absolute variation or dispersion of 200 feet of altitude for a mean value of 500 ft would have a much different significance than 200 feet dispersion for a mean value of 5000 feet. The landform indicated in the first instance, would very probably be a fairly dissected region, while in the second case, a relatively well preserved plateau surface.is indicated.

A measure of relative dispersion may be computed, termed the <u>coefficient of variation</u> (V), from: $V = \frac{S}{\bar{X}}$.

3.3-(4) Measures of symmetry.

The sample parameters discussed under this heading are in actuality dispersion indices. However, since they are also highly descriptive of the variability of distribution form, they are listed separately.

a) Skewness:

Skewness is the degree of asymmetry, or the amount of departure from symmetry, of a frequency-distribution. The value of a coefficient of skewness describes the extent of the presence of a 'tail' of extreme values. A positive skewness means that a tailing of extremes is present at the upper end of the range, while negative skewness indicates extreme values at the lower end. For a perfectly symmetrical distribution, skewness would be equal to zero.

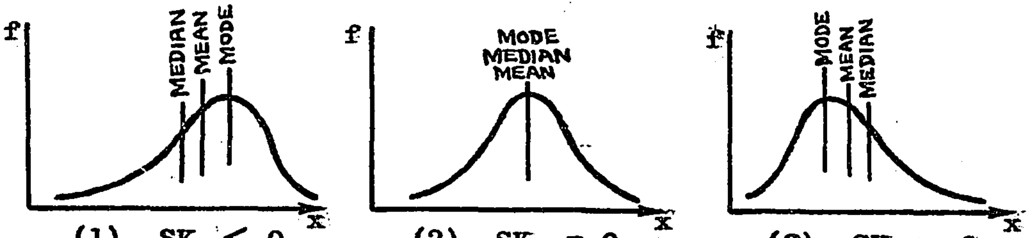
The coefficient of skewness is defined in terms of the third moment of the distribution about the arithmetic mean and is computed from:

$$SK_m = \frac{m_3}{(S)^3}$$

where: SK_m = moment coefficient of skewness.

$m_3 = \frac{\sum f(X-\overline{X})^3}{N}$ = the third moment about the arithmetic mean.

S = standard deviation.



(1) $SK_m < 0$ (2) $SK_m = 0$ (3) $SK_m > 0$

Figure 7 - Hypothetical unimodal (1) negative, (2) symmetrical, and (3) positive skewed frequency distributions. Note the relative positions of the mode, median and arithmetic mean.

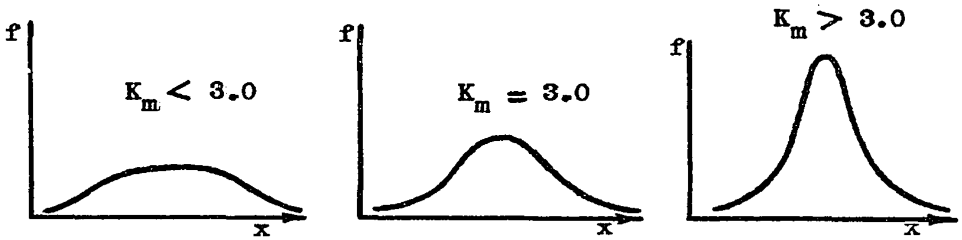
b) Kurtosis:

Kurtosis is the degree of peakedness of a frequency-distribution, usually considered relative to the normal curve of probability theory. It is a measure of the sorting in the extremes of the distribution. A normal curve (Dixon and Massey, 1957, p. 48-66) has a moment coefficient of kurtosis equal to 3.0 and is called mesokurtic ; when the value is less than 3.0 or greater than 3.0, the curves are termed platykurtic and leptokurtic, respectively.

The above named moment coefficient of kurtosis is the most useful index of the value of peakedness of a frequency-distribution curve, and is based on the fourth moment measure of the distribution. It is computed from:

$$K_m = \frac{m_4}{(S)^4}$$

where: K_m = moment coefficient of kurtosis.
$m_4 = \frac{\Sigma f(X-\bar{X})^4}{N}$ = the fourth moment about the arithmetic mean.
S = standard deviation.



(1) (2) (3)

Figure 8 - Hypothetical unimodal (1) platykurtic (2) mesokurtic, and (3) leptokurtic frequency-distributions.

c) Moment measures:

Moment measures of the sample distribution were mentioned in the discussion of skewness and kurtosis. Moments are precision indices and allow a more precise comparison of frequency distributions. They are also useful in the fitting of a theoretical curve to an actual observed sample distribution. Moments are calculated analogous to the computation of moments of torque in mechanical physics, and can be taken about any point in the distribution. The most useful moment measures are those taken about the arithmetic mean. They are computed from grouped data, by the following formulae:

$$m_1 = \frac{\sum f(X-\overline{X})}{N} \qquad m_3 = \frac{\sum f(X-\overline{X})^3}{N}$$

$$m_2 = \frac{\sum f(X-\overline{X})^2}{N} \qquad m_4 = \frac{\sum f(X-\overline{X})^4}{N}$$

The first moment is the arithmetic mean and is equal to zero when the mean is used as the centre of moments. The second moment about the arithmetic mean is recognized as the square of the standard deviation (S^2), the variance.

Moment measures are used in the computation of the best value of skewness and kurtosis coefficients and in fitting a theoretical curve to the observed sample frequency distribution.

3.3-(5) Fitting of a theoretical population curve.

A method of fitting a theoretical population frequency curve to the observed sample data is given by Elderton (1938). The "curve type criteria" are calculated from moment measures of the observed distribution, and are compared with standards given from theoretical considerations. Three main types of frequency curves are available. and nine "transitional" cases. The curves are termed "Pearson curves", after the pioneer worker in statistical mathematics.

Theoretically, the population characteristics are defined in the Pearson system by the following parameters:

$$\beta_1 = \frac{m_3}{(m_2)^3} \quad , \quad \beta_2 = \frac{m_4}{(m_2)^2} = \frac{m_4}{S^4}$$

and

$$K = \frac{\beta_1(\beta_2^2 + 3)^2}{4(4\beta_2 - 3\beta_1)(2\beta_2 - 3\beta_1 - 6)}$$

where: β_1 = Curve criterion measure of skewness.

β_2 = Curve criterion measure of kurtosis.

K = Curve criterion.

The method is described in Kendall (1947); Elderton (1938, table VI opp. p. 51) provides a tabulation of the range values of the above parameters, and gives the equations of curves of the represented types. Tanner (1959), has written on the application of Pearson curves in representing geomorphological populations (short note).

3.3-(6) Summary:

Values were calculated for most of the above named sample frequency distribution parameters. Under the guidance of the staff of the McGill Computer Centre, and particularly Miss J. Keeling, programmer, a fortran program was written and run on the 7044 digital computer (the program is included in appendix-D).

3.4 Geomorphic meaning of parameters.

3.4-(1) The sample.

The sample governs our interpretation of the population. The size of samples is important, for small samples may have regional characteristics which might mask those of the true population. The equilibrium between process and bedrock may be poorly established in a finite area and the topography developed may not be representative for the rock type. Statistically, small samples require special techniques of handling, because the continuity of the distribution and the approximation of the sample to the population is not strong and becomes weaker with decreasing value of N. The value N= 30 is considered the lower limit of "large samples" (Spiegel, 1961, p. 188).

The samples taken from the populations of altitude supported by various rock formations in western Gaspé have a size range of 26 to 2350 altitude counts. Fourty five samples of the total fifty-five have altitude counts in the range 39 - 500; only one (the area of Ste. Marguerite volcanic rocks in the Causapscal East map-area) has a coverage of less than 30 grid intersections (it has 26). The actual size frequency breakdown of samples is shown graphically in figure 9, p. 51.

Thus, for practical purposes, all samples obtained in this study are of the "large sample" category.

It is important to know whether the sample characteristics are representative of those of the population. Statistically, the problem is resolved by fitting a theoretical population curve to the data and then computing the goodness of fit. This has not been attempted for the data obtained in this study which is of a preliminary nature. Representative sampling has been discussed in section 3.2-(2), p. 36-37, in terms of sampling grid-mesh size only. The samples are considered to adequately represent the populations from which they were drawn.

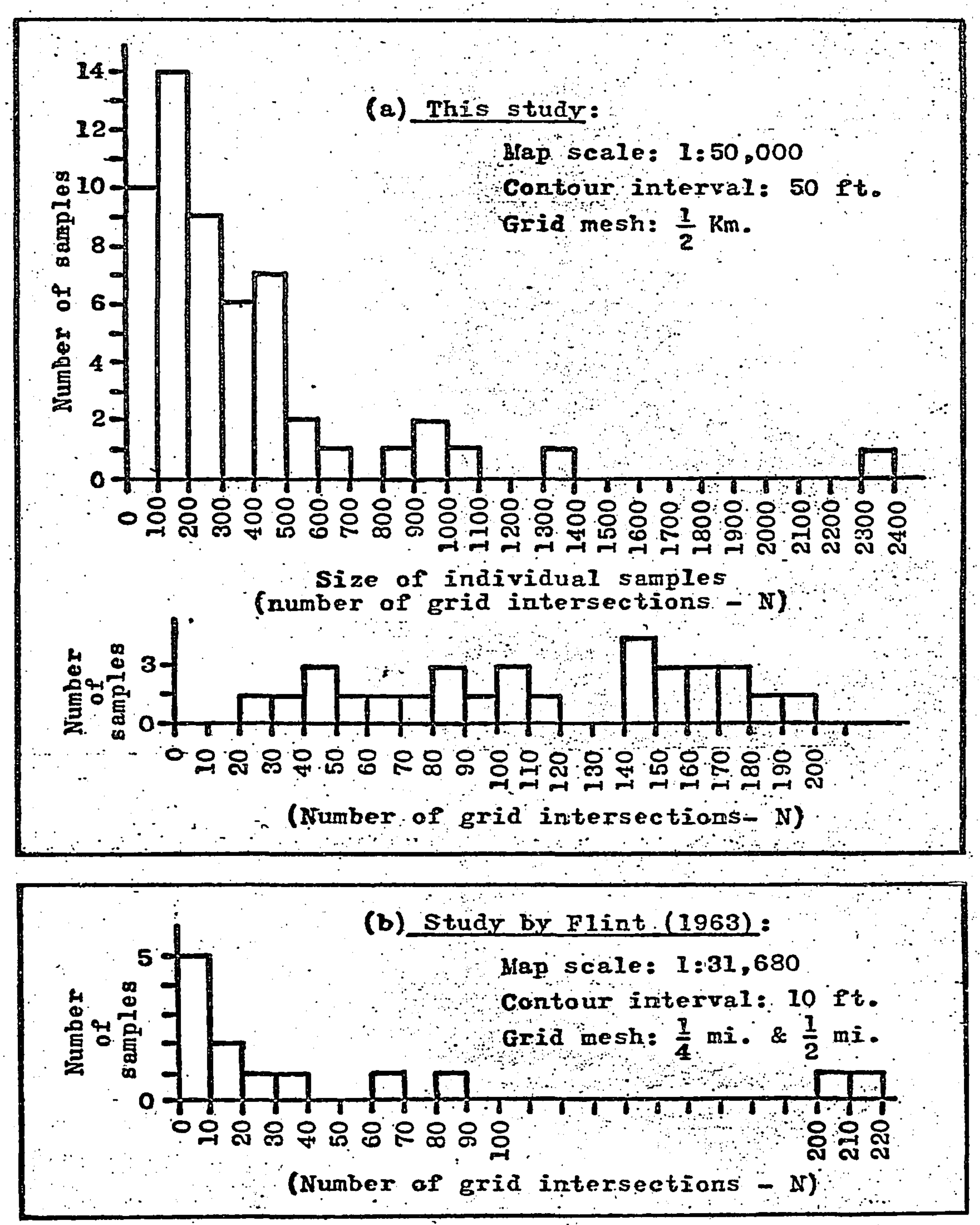


Figure 9 - Size distribution of samples.

A sample may be considered in parts, if desired, by the method of "stratified sampling" (Krumbein and Graybill, 1965, p. 156). This was used for unit 5 (the Lake Branch formation) in the Big Berry Mountains West map-area. The method is to "slice" or subdivide the population area and to develop frequency distributions for each part and then compare. In much the similar manner, the Tabletop granite was considered in two parts (cirque areas and the regular topography); and in the Oak Bay map-area, the topography developed on the footwall and hanging wall parts of a formation cut by a mapped thrust fault, were studied.

Stratified sampling of the Lake Branch formation is discussed further in section 3.4-(3), p. 55.

3.4-(2) Theoretical population curve (Pearson curves).

Topography depicted by contours is a continuous series of altitudes. Thus a sample cannot have a distribution such as shown by figure 6-2, p. 45. However, the sample might show a less than smooth continuity, and therefore the question arises whether we are able to use the data of the sample as that of the population. We may calculate the theoretical population curve to fit the data; and the degree or goodness of fit. This will be carried out in part, not for the reason given above, for the samples are considered representational, but for a check of Tanner's contention that a "representational geomorphic profile" belongs to the class of Pearson's Type-I or Type-IV curves (Tanner, 1959a, p. 458; see also 1959b and 1962). The Pearson system of frequency curves is discussed in detail by Elderton,(1938) and described by Kendall (1947).

The curve type which best fit an altitude distribution was determined for all samples by the method given on p. 48-49. 46 of the total 55 curves were found to belong to the Type-I family and 6 were Type-IV; one Type-II, one Type-VI, and one Type-VII were also found. All these are non-Gaussian distributions. Thus, Tanner's view seems to be validated.

Table D-2 of appendix-D lists the calculated curve type data; and appendix-C shows the plotted ("zig-zag") curves.

A representative series of Type-I curves may be seen from figure C-5 in appendix-C.

The departure of the observed data from a Gaussian "normal" distribution of frequencies can also be calculated. Most statistical text books have tables included in the appendix, by which an approximate determination of the degree of fit can be made on the basis of skewness and kurtosis values, at chosen levels of significance. For present purposes, a visual approximation suffices and may be made from curves included as appendix-C. The curve that most nearly approximates a normal distribution is observed to be that for the area underlain by rocks of the Jonathan formation in the Rivière Angers East map-area (figure C-4, no.2, appendix-C; see also map 4, unit 2). The frequency distribution of altitudes of the sample from this area has a non-skewed and slightly mesokurtic character and represents a topographic surface which has a fairly dissected appearance and is made up mostly of slope facets. This may point to a possible correlation of the normal curve with maturely dissected topography.

The fitting of a theoretical curve from classical frequency distribution theory (Pearsonian system) can be made for any distribution. Further analysis might consider the approximation of the non-"normal" curves by two or more components of normal Gaussian curves and the correlation of parts of the topography of the sample area to these. The reader is referred to Tanner (1959b; and 1962, and references given therein) for some suggestions on this account.

3.4-(3) Geomorphic significance of average altitude parameters.

The several possible measures of central tendency of a sampled frequency distribution of altitudes reflect vastly dissimilar characteristics of the altitude population defining the topography. Each will be discussed in some detail:

a) The arithmetic mean altitude:

The arithmetic mean altitude is computed as the centre of mass of a structure of frequency distribution of altitudes. Therefore, its value represents the average land height of the crustal block enclosed within the boundaries of the area sampled. It is a value computed from every altitude occurrence in the sample area and is a computational average of positional height; it gives no indication of the shape of the landform.

Because it is a mass-average, the value of the arithmetic mean altitude seems a good index for comparison of the relative erodibility or the resistance to erosion, of rock units.

Values for the arithmetic mean were computed for all sample units and are tabulated in table D-1, appendix-D. In figure 10, p. 56, they are plotted in the form of a bar graph, with the mean altitudes of the rock units grouped according to map-area and the map-areas arranged in two north-south lines.

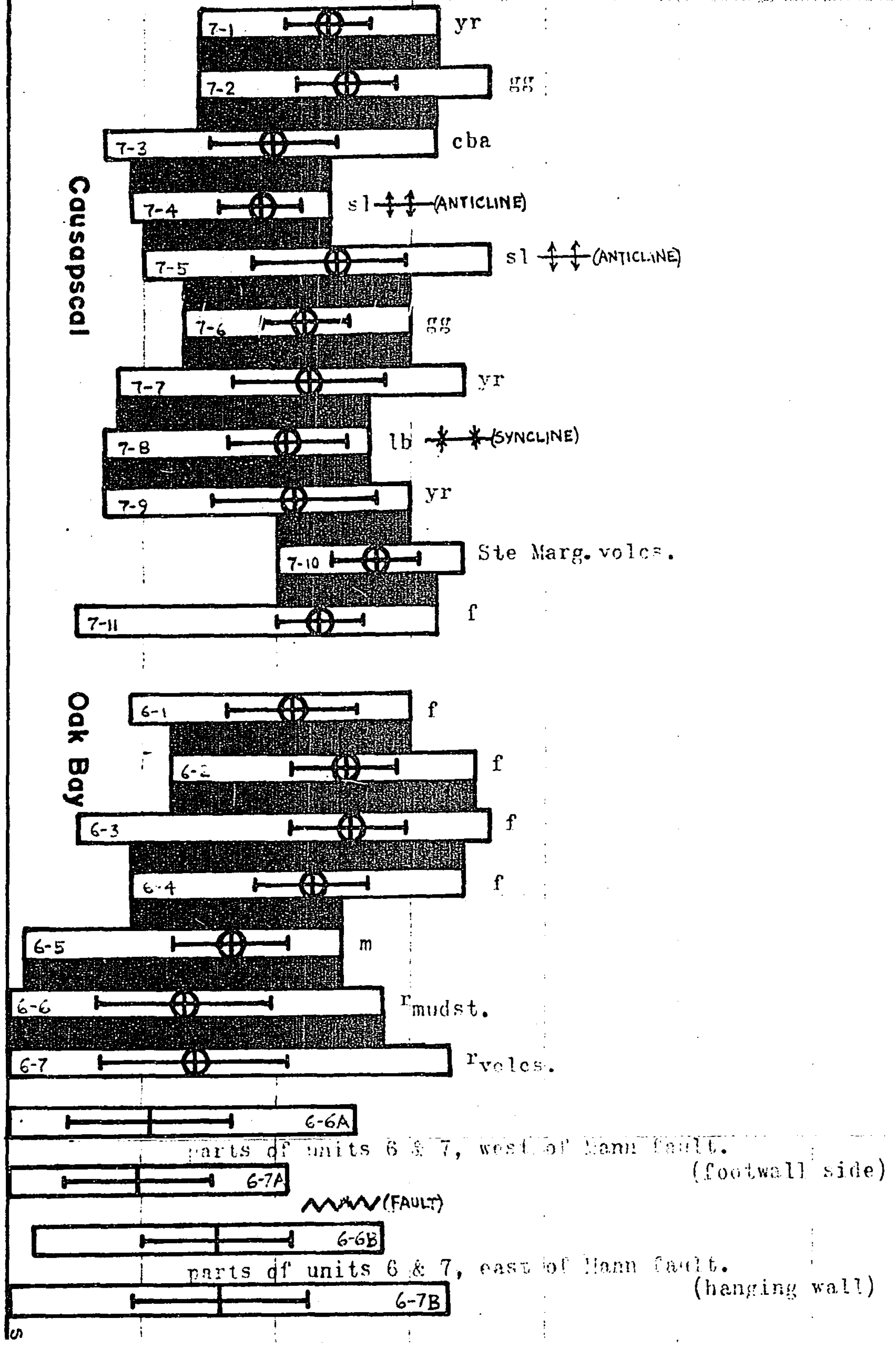
In western Gaspé, the mean altitude of landmass has a remarkably narrow range. Figure 10-a shows that in the most westerly map-areas, almost all the rock units support arithmetic mean altitudes in the interval 900 - 1400 ft above mean sea level; 22 of 27 rock units fall into this group. The only exceptions are the Shickshock metavolcanics, the St. Leon formation where it is bounded by the major South Shickshock Fault, and the Matapedia Gr limestones and Restigouche Gr mudstones and volcanic sequence bordering Chaleur Bay. In the Causapscal East area, 10 of 11 rock units have a range of 350 ft (from 900 to 1250 ft); the exception is a narrow band of Ste. Marguerite volcanics, which is slightly higher.

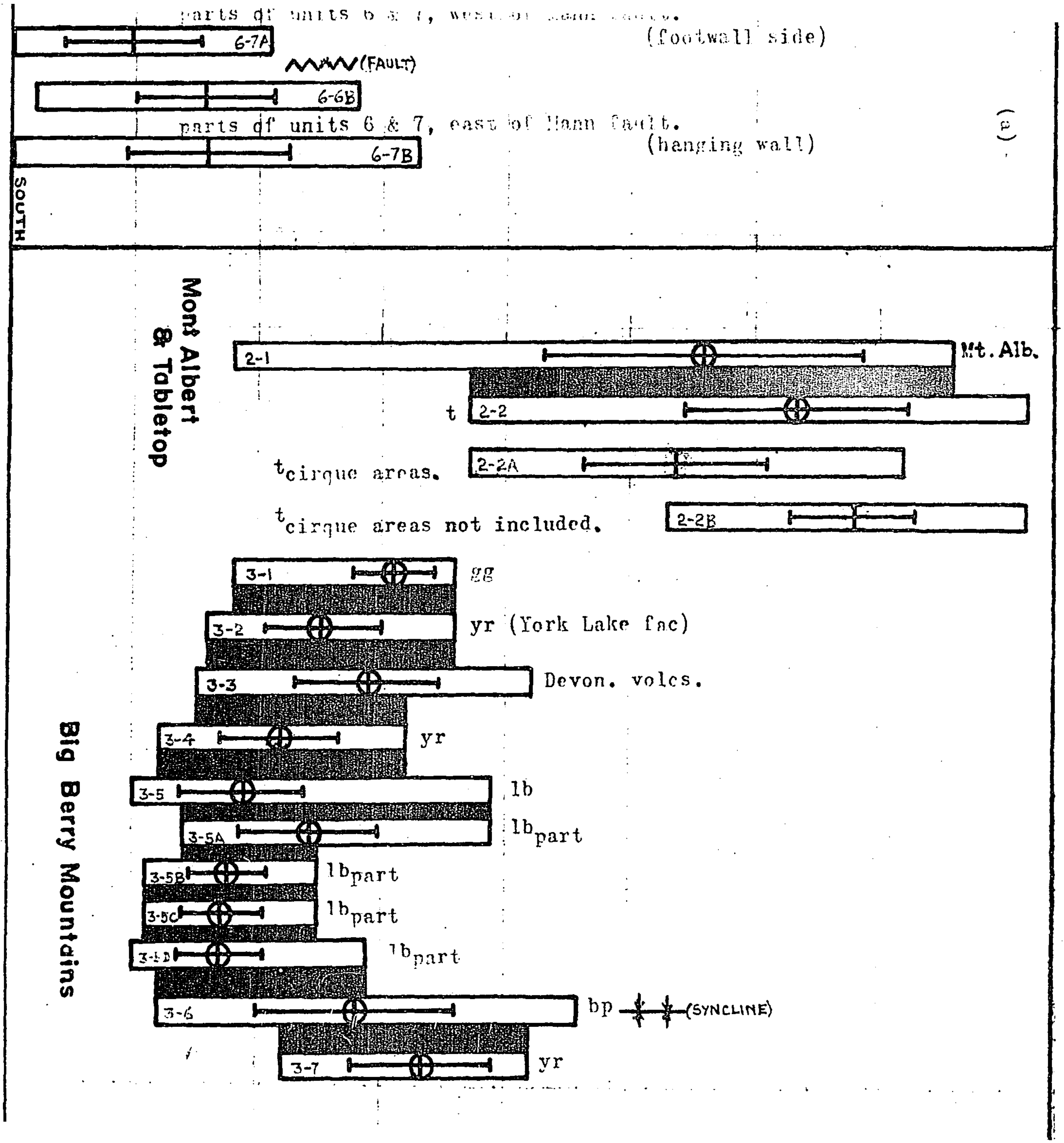
Notwithstanding the narrow range into which the mean altitudes fall and the various structural controls (major faults and folds), diagram 10-a points to a consistent relationship for altitudes supported by different lithologies. Within each of the map-areas, the Grande Grève formation always supports a higher mean altitude than the York River, which in turn is always higher than the Cape Bon Ami, followed by the St. Leon, and so on. That these formations have a constant relative altitudinal position, as indicated by the index of arithmetic mean altitude, is clearly empirical proof that in this area, lithology does exert a control over topography. A corollary is that the rocks must exhibit a varying reaction to the influence of processes tending to reduce them to a lower mean altitude, i.e., there is relative erodibility.

Figure 10-b shows a roughly similar relationship as that described for figure 10-a but it is not as clearly defined. This was expected and is attributed to the structural control exerted by the Gaspé Syncline.

Structural control due to faulting is also clearly indicated, in western Gaspé. By comparing the arithmetic mean altitude values of adjacent formations, situated on opposite sides of a mapped fault, it is seen that in all cases, the formation situated to the south supports a topography with a higher mean altitude than that of topography developed on the formation situated to the north of the fault. (Compare units 8-2 and 8-3; 6-6 and 6-7; 4-5 and 4-6; possibly 1-4 and 1-5, and also 3-5 and 3-6, of figure 10, page 56). It seems likely that these are thrust faults in which the thrust forces have originated from the south or south-east; it may be that thrust faulting is an important structural control of topographic development in western Gaspé.

The migration of the mean altitude may be observed by applying the technique of "stratified sampling" (see p. 52). If a topography is suspected to have special trends, then these may be studied by slicing the total population into parts and developing frequency distributions. In the Big Berry Mountains West map-area,(figure B-3, Appendix-B), the Lake Branch red-beds (unit 3-5; map-3) are observed from the topographic map to have a gradually decreasing altitude from the western mountainous region to the east, where the Cascapedia River flows through the area. Histograms were developed for arbitrary areas (of 10-line blocks of grid-intersection points, from west to east) and the results plotted in figure B-3, Appendix-B.

Causapscal
7-1
yr
7-2
gg
7-3
cba
7-4
sl (ANTICLINE)
7-5
sl (ANTICLINE)
7-6
gg
7-7
yr
7-8
lb (SYNCLINE)
7-9
yr
7-10
Ste Marg. volcs.
7-11
f
Oak Bay
6-1
f
6-2
f
6-3
f
6-4
f
6-5
m
6-6
rmudst.
6-7
rvolcs.
6-6A
parts of units 6 & 7, west of Mann fault.
(footwall side)
6-7A
(FAULT)
6-6B
parts of units 6 & 7, east of Mann fault.
(hanging wall)
6-7B
S


parts of units 6 & 7, west of Mann fault.
6-7A
(footwall side)
(FAULT)
6-6B
parts of units 6 & 7, east of Mann fault.
(hanging wall)
6-7B
SOUTH
(a)
Mont Albert & Tabletop
2-1
Mt. Alb.
t
2-2
2-2A
tcirque areas.
tcirque areas not included.
2-2B
Big Berry Mountains
3-1
gg
3-2
yr (York Lake fac)
3-3
Devon. volcs.
3-4
yr
3-5
lb
3-5A
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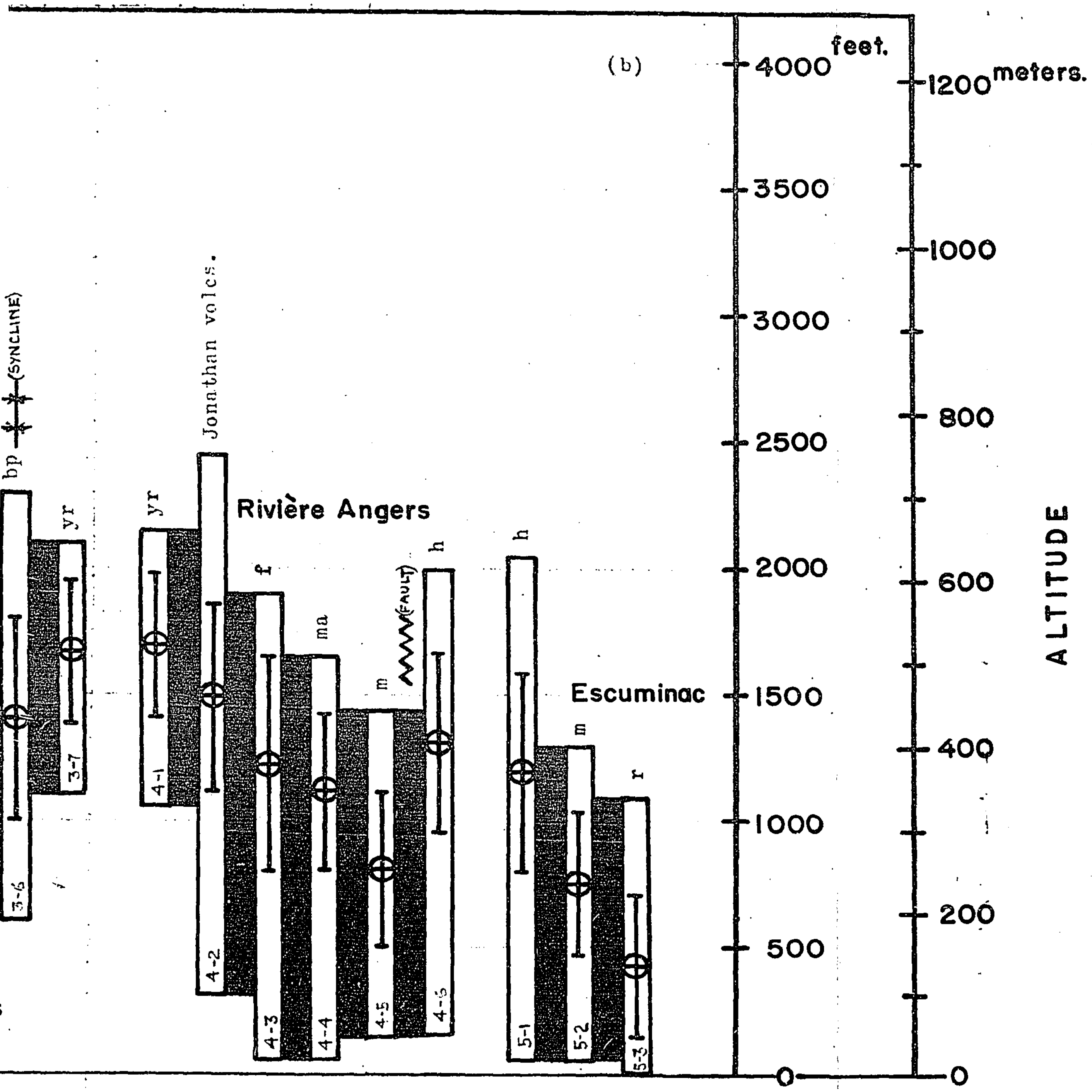
3-5B
lbpart
3-5C
lbpart
3-5D
lbpart
3-6
bp
(SYNCLINE)
3-7
yr


(b)
feet.
4000
3500
3000
2500
2000
1500
1000
500
0
1200
meters.
1000
800
600
400
200
0
ALTITUDE
bp
(SYNCLINE)
yr
yr
Jonathan volcs.
Rivière Angers
f
ma
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m
r
3-6
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4-4
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5-1
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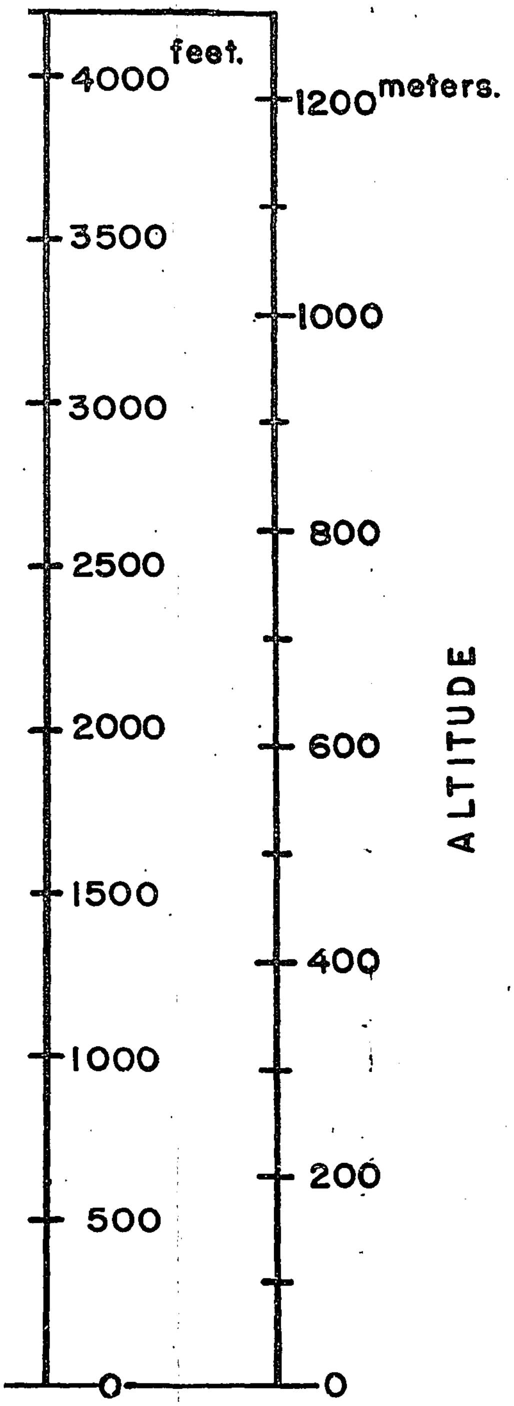
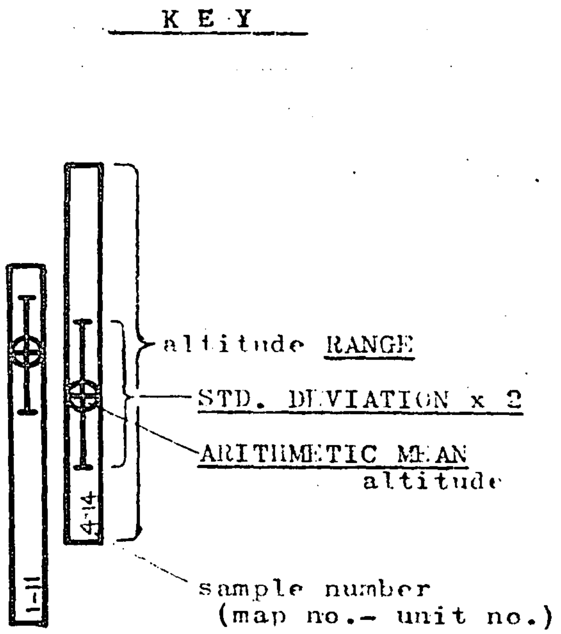
5-3

No

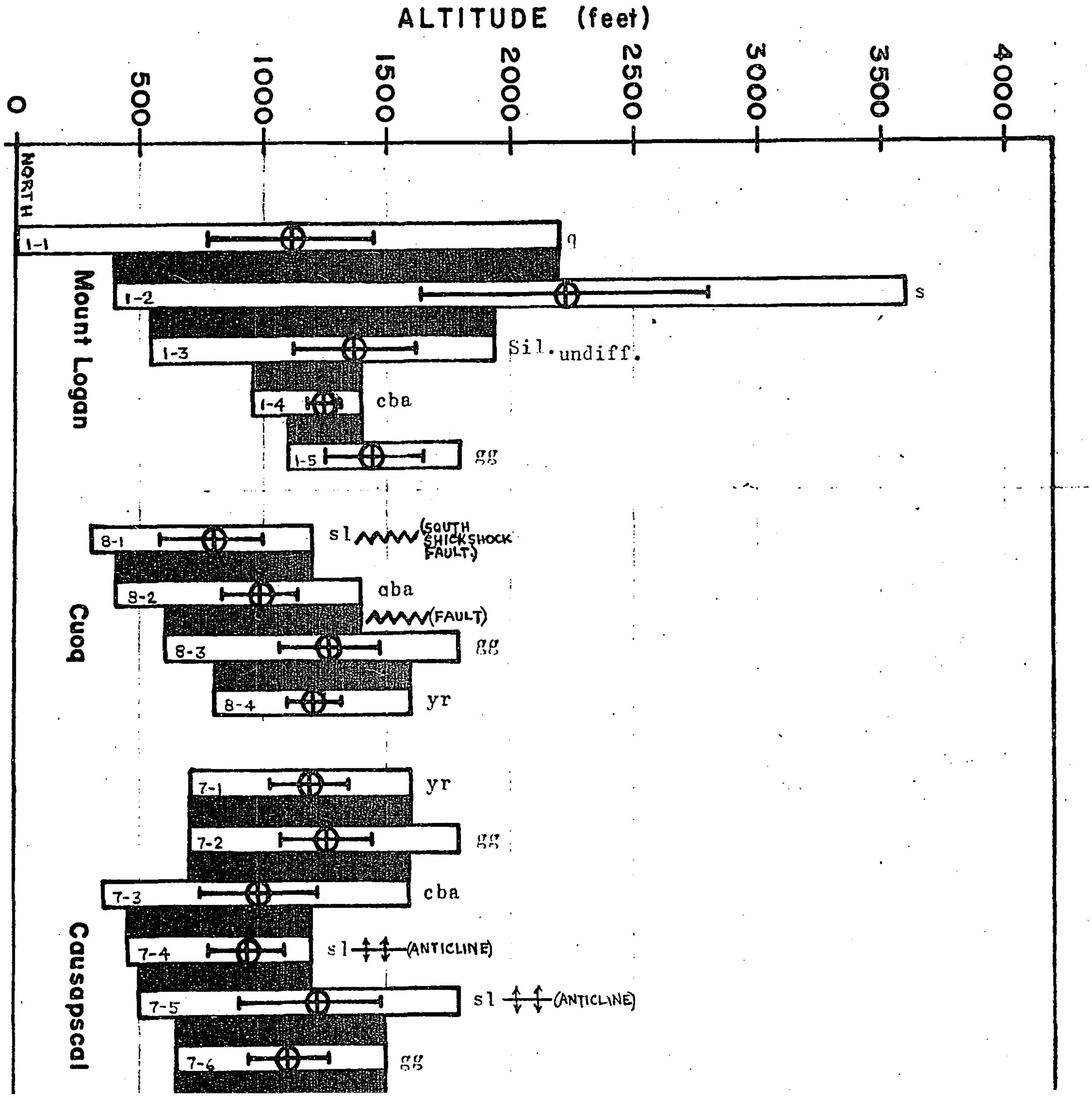
Fi

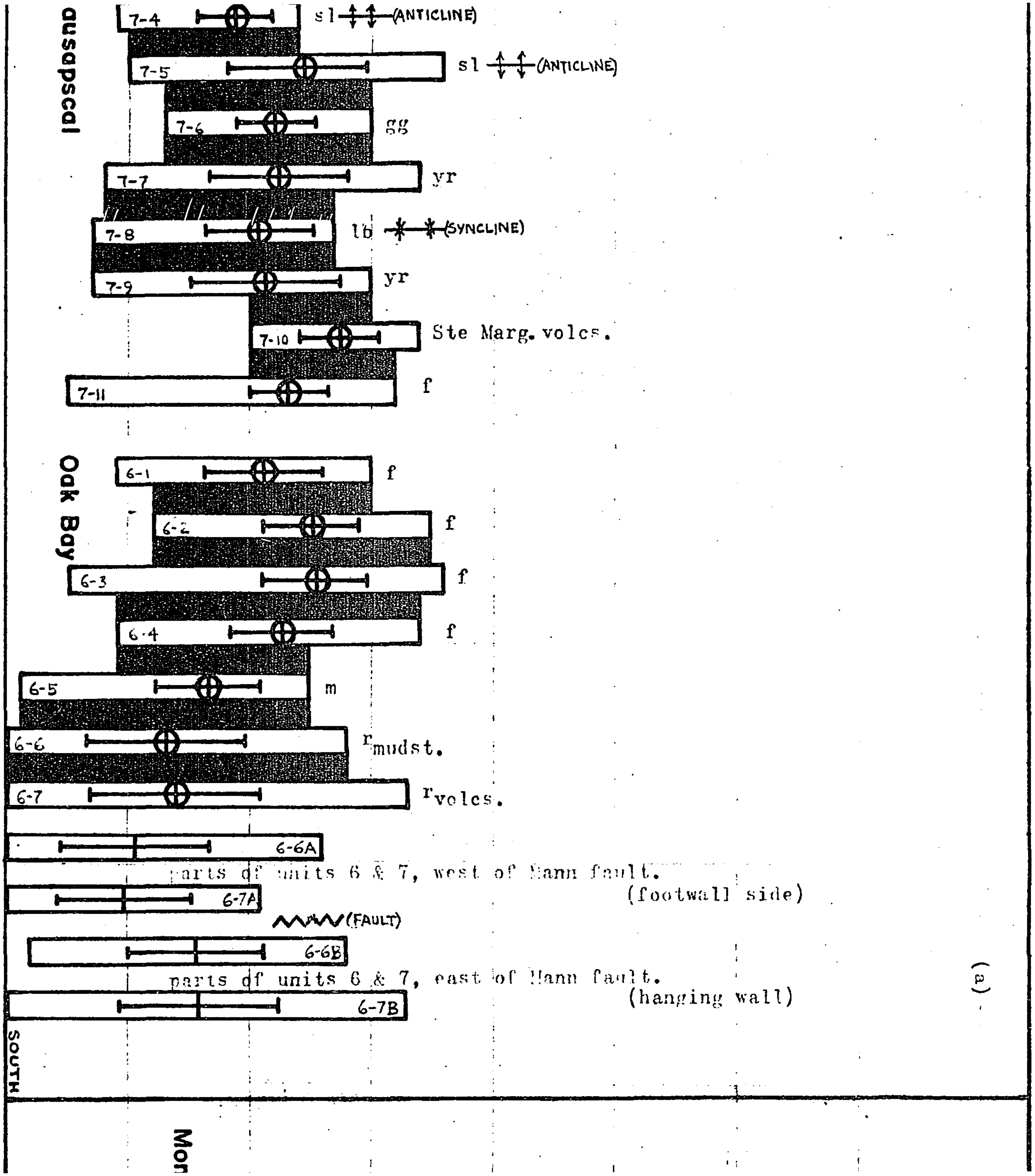




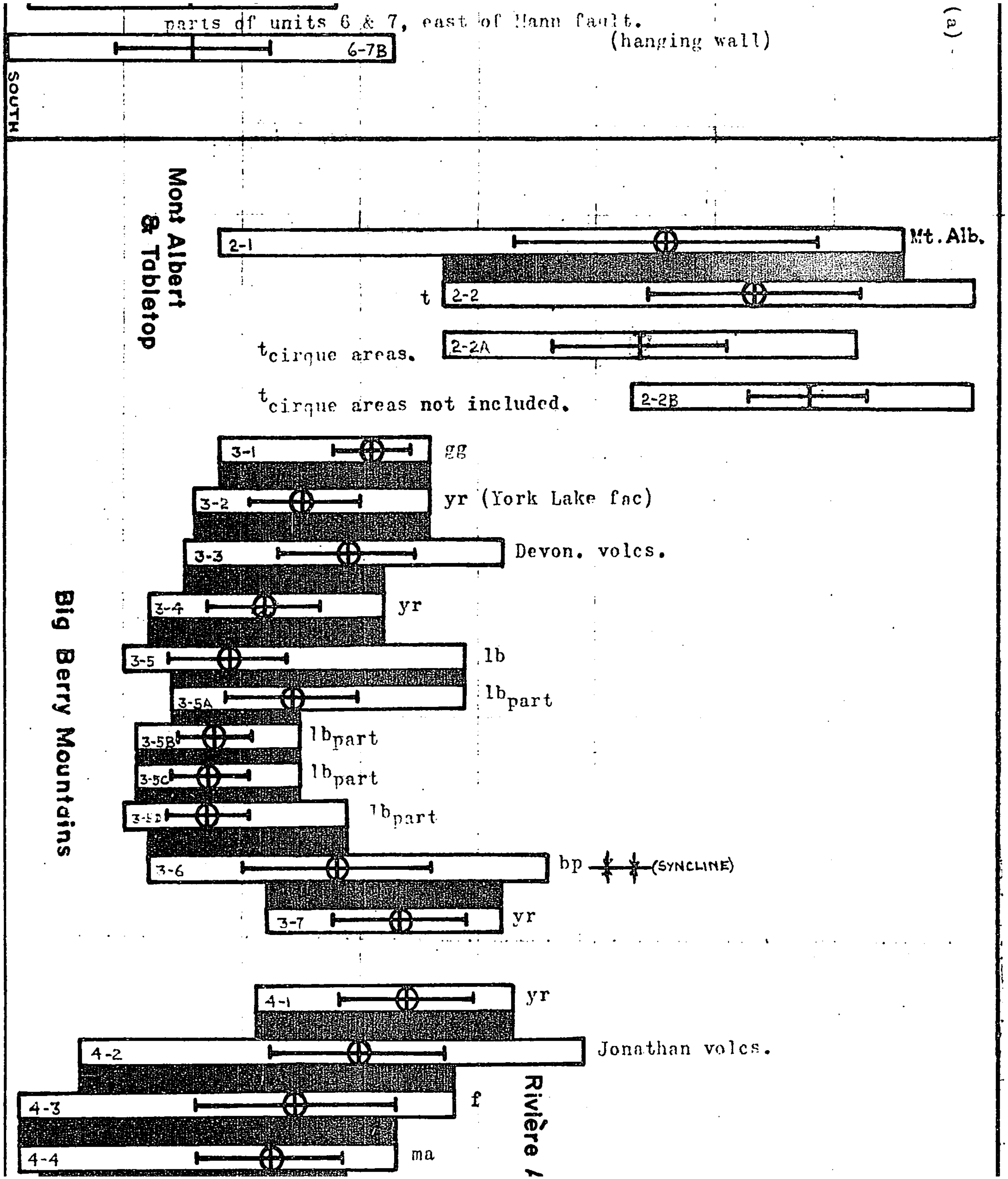
Note: letter designation of rock units is the same as given on page 13 and for map no. 9 in the back pocket.

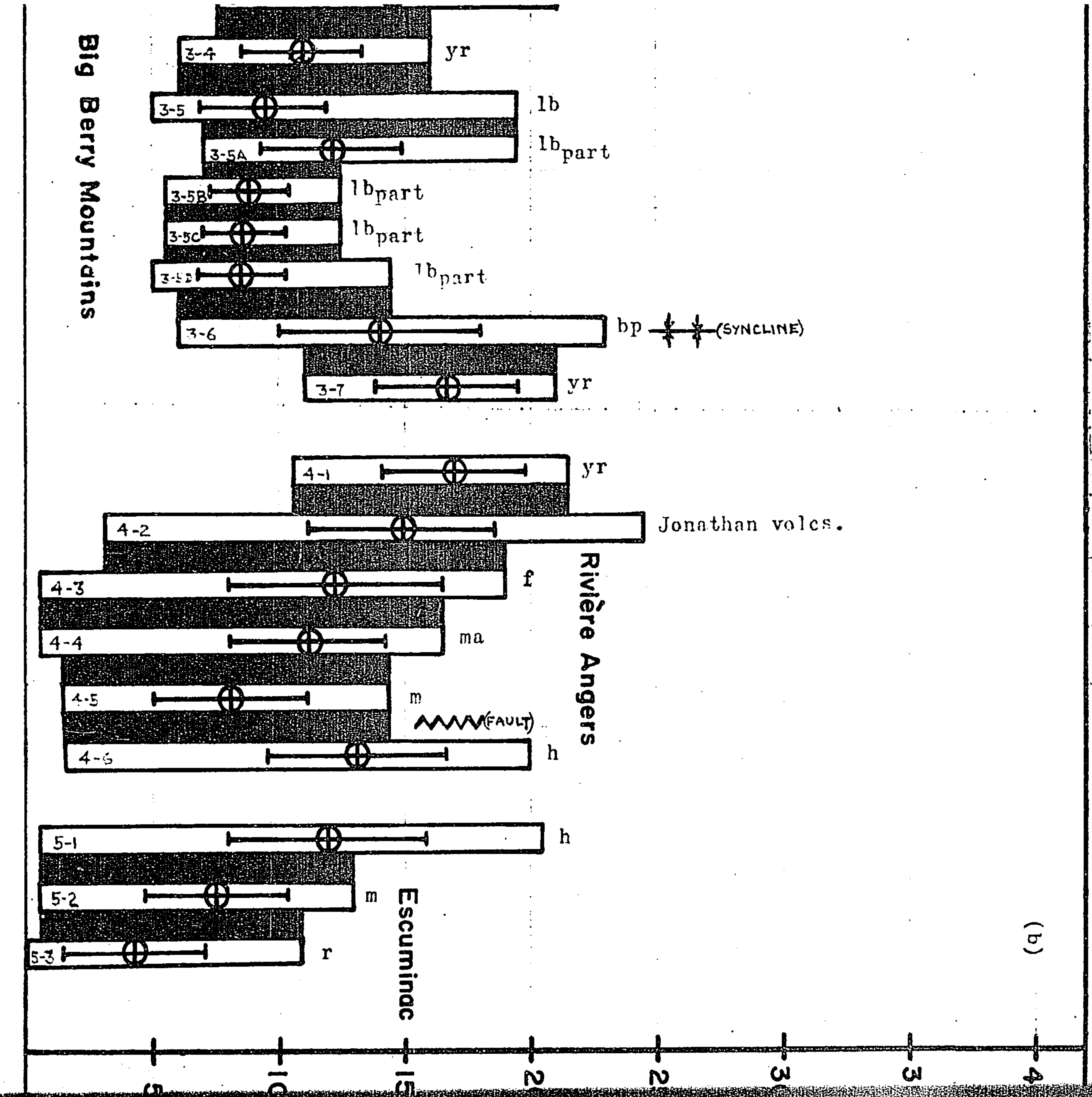
Figure 10 .- Plot of Arithmetic Mean Altitude, Standard Deviation, and Range of sample units grouped by map sheet.


ALTITUDE (feet)
0
500
1000
1500
2000
2500
3000
3500
4000
NORTH
Mount Logan
1-1
q
1-2
s
1-3
Sil. undiff.
1-4
cba
1-5
gg
Cuoq
8-1
sl
(SOUTH SHICKSHOCK FAULT)
8-2
cba
(FAULT)
8-3
gg
8-4
yr
Causapscal
7-1
yr
7-2
gg
7-3
cba
7-4
sl
(ANTICLINE)
7-5
sl
(ANTICLINE)
7-6
gg



ausapscal
7-4
sl (ANTICLINE)
7-5
sl (ANTICLINE)
7-6
gg
7-7
yr
7-8
lb (SYNCLINE)
7-9
yr
7-10
Ste Marg. volcs.
7-11
f
Oak Bay
6-1
f
6-2
f
6-3
f
6-4
f
6-5
m
6-6
r mudst.
6-7
r volcs.
6-6A
parts of units 6 & 7, west of Mann fault.
(footwall side)
6-7A
(FAULT)
6-6B
parts of units 6 & 7, east of Mann fault.
(hanging wall)
6-7B
SOUTH
Mon
(a)


parts of units 6 & 7, east of Mann fault.
(hanging wall)
(a)
6-7B
SOUTH
Mont Albert & Tabletop
2-1
Mt. Alb.
t
2-2
2-2A
t cirque areas.
2-2B
t cirque areas not included.
Big Berry Mountains
3-1
gg
3-2
yr (York Lake fac)
3-3
Devon. volcs.
3-4
yr
3-5
lb
3-5A
lb part
3-5B
lb part
3-5C
lb part
3-5D
lb part
3-6
bp
(SYNCLINE)
3-7
yr
4-1
yr
4-2
Jonathan volcs.
4-3
f
4-4
ma
Rivière



Big Berry Mountains
3-4
yr
3-5
lb
3-5A
lbpart
3-5B
lbpart
3-5C
lbpart
3-5D
lbpart
3-6
bp
(SYNCLINE)
3-7
yr
4-1
yr
4-2
Jonathan volcs.
Rivière Angers
4-3
f
4-4
ma
4-5
m
(FAULT)
4-6
h
5-1
h
5-2
m
Escuminac
5-3
r
(b)
5
10
15
2
2
3
3
4

The migration of the arithmetic mean altitude and the mode(s) are clearly shown. The means have a trend decreasing in value towards the major stream (Cascapedia River). The geomorphic meaning, here, is the reflection of the control exerted by adjacent lithologies and the control of topography by major streams. Apart from the Cascapedia River, three other major streams traverse the outcrop area of the Lake Branch formation: the Miner Brook, flowing NW to SE at about the middle-to-south part of the area; the Go-A-Shore Brook, also flowing NW to SE, at about the central part of the area; and the Cascapedia River Lake Branch which flows longitudinally through the area, from SW to NE. The first (most westerly) stratified sample count (part 5A of figure B-3, appendix-B) yielded altitudes ranging up to 1900 ft with a mean altitude of 1221.3 ft; this approximates the altitudinal position of the adjacent and higher units: Battery Point formation ($\bar{x}$ = 1403.3 ft) and the adjacent York River formation ($\bar{x}$ = 1091.4 ft). No major streams cross the area of the first sample, and the interpretation is that altitude here is controlled by the bedrock resistance and the effect of adjacent resistant ("ridge-making") lithologies. The second stratified sample count is over an area through which the Miner Brook and the Cascapedia River Lake Branch Brook flow. The topography supported in this area has a maximum altitude of only 1250 ft with a mean of 884.3 ft, both noticeably lower than for the previous sample. The interpretation is that altitude here is controlled mostly by the bedrock resistance alone. The third "slice" has a structure of frequencies almost exactly similar to that of the second count and only a slightly lower mean altitude, at 865.3 ft. This would seem to indicate that bedrock resistance and stream erosion, mass wasting and weathering are in some sort of quasi-equilibrium, and that the effect of more resistant adjacent formations is relatively of no consequence. The frequency distribution of altitudes of the fourth and final (most easterly) stratified sample count shows the effect of the major stream flowing through that area. The mean altitude however, is only slightly lower, at 806.1 ft.

Clearly, the topographic development on the Lake Branch formation, in the Big Berry Mountains West map-area, is controlled in the westernmost part by the adjacent more-resistant lithologies. East of Miner Brook, the mean altitude is constant for the sliced populations, and the erosional topography is dependent only on the characteristic resistance to erosion of the bedrock material. The interpretation given is backed up by the plots of altitude frequency distribution curves in figure C-5 of appendix-C. Curves 5B, 5C and 5D have similar frequency distributions, while that of curve 5D is different, more complex, and resembles the curves drawn for units 4 and 6 (York River and Battery Point formations, adjacent to the Lake Branch formation). The distribution of unit 5A seems to be made up of two or more components, while curves 5B, 5C and 5D show a single trend and lie in close proximity, away from unit 5A. The trends of 5B, 5C and 5D are correlated to topography controlled by a single rock type.

A modified method of "sliced populations" was used in the analysis of the frequency distribution of altitudes for the Tabletop granite block, in the Mont Albert-Tabletop map-area (map-2). Cirques were noticed to be prominent at the sides of the Tabletop block, and were observed to have a uniformly different topography (arrangement of altitudes) from the assumed fluvially-derived topography of the gently rolling upland of the block. The total population underlain by the granite was considered made up of two subpopulations, and frequency distributions of altitude were counted for both parts and the whole.(See histograms in figure B-2, appendix-B). The cirque areas had a considerably lower mean altitude value (2680.9 ft) than the fluvial topography (3402.7 ft); a mean value of 3166.2 ft was obtained for the whole. The cumulative percent-frequency curves (figure C-2 of appendix-C) clearly show the presence of two well-defined subpopulations, one of which is due to glacial action; the other is due to fluvial processes. There is a definite similarity between the curves of the Mont Albert peridotite and the Tabletop granite - thus, it is likely that both have subpopulations derived from glaciation. Therefore, in comparing the altitude of different rock units, it must be ascertained that the topography of each has developed in a similar manner and under the same general conditions of erosion. An important corollary is that the environment of topographic development may be reflected by the altitude population, much as in the case of environment of deposition reflected from grain size of sediments (Folk and Ward, 1957; Friedman, 1961, 1962).

The above discussion also points out one limitation of the arithmetic mean - there is no selectivity - all altitudes of the sample have an influence on its value. Therefore, the arithmetic means of only identically derived populations can be subjected to valid comparison. This has an important bearing in using the values of the arithmetic mean altitude as the index of relative erodibility.

b) The altitude-mode and "modal tendency":

The mode of a frequency distribution of altitudes is the altitude value which is found to occur most often. It is an indication of the preference in the occurrence of altitudes in a topography. In most cases, its value correlates with some predominantly flat area of the land, such as an upland surface or a broad valley bottom or a gentle lowland. However, the mode is also found to be developed for frequency distributions of altitude for areas where no flat surfaces are present - where topography is made up of fairly steep, straight slope-facets only (for example, the area underlain by the Jonathan formation, unit-2 of map-4; refer to figure 11d, p.62).

A frequency distribution may be unimodal, bimodal, or with several modes. There may be one well-developed mode and one or more subsidiary modes; or there may be several modes none of which is more well-developed than the others. All these categories may be seen from the figures of histograms in appendix-B and from the percent-relative-frequency histograms of figure 11, p.62.

Although the mode is simply defined, the geomorphic meaning of a modal altitude is not as easily visualized as that of the arithmetic mean altitude. To simplify, frequently it is more useful to speak in terms of the "modal tendency" which is defined as the indication of a mode stated in terms of several class intervals of altitude. In most instances, the mode signifies flat areas present in the landscape: it does not however, indicate such things as the highest surface plane of an upland; rather, it gives the altitude at which there is the greatest area. For instance, in the sample unit 6-5 (see map-6 and figure 11d, p.62), there is present a very well defined upland surface which is traversed and cut by several narrow, steep-sided, V-shaped valleys. The upland is at an altitude of 900-1150 ft but the mode is found to be at about 900-1000 ft; the modal tendency can be placed between the limits 800-1050 ft - at the lower limit of which is found the major break in slope - above 800 ft lie convex slopes and the flat upland, and below which are found steep, straight slopes and the concave slopes leading to the narrow valley-bottom lowlands. Thus, while the mode is not precise in defining the upland, it may be useful in helping to assign the altitude of the boundary between two domains of different slope types.

The modal altitudes of all sample frequency distributions are shown by the histograms found in appendix-B, and some percent-relative-frequency histograms plotted for selected units, in figure 11, p.62. While some units have unimodal distributions, most are seen to be polymodal.

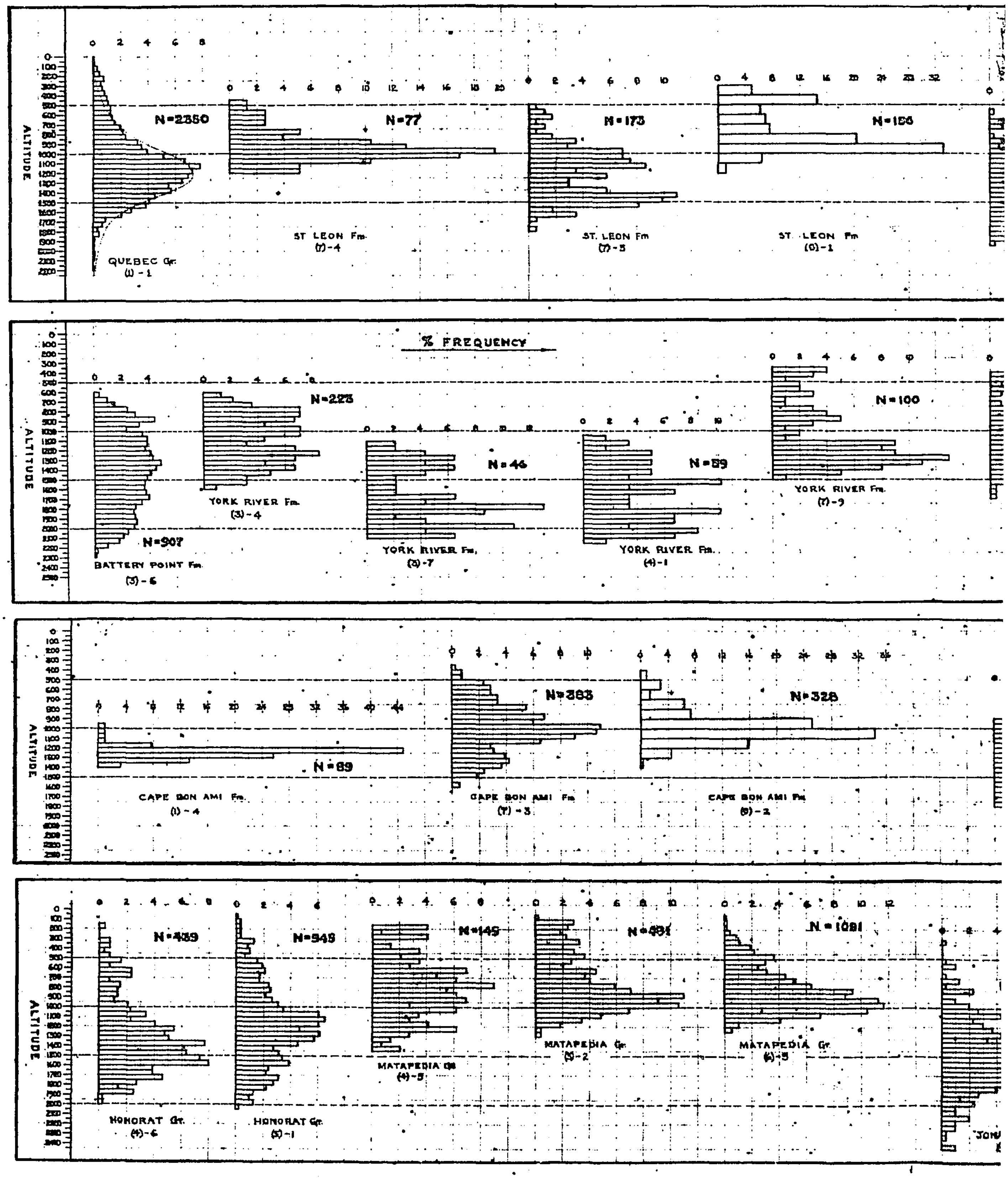
A polymodal distribution may be explained by correlating each of the observed modes with topography shown on the contour maps. There are some cases where the sample is simply too small to have a uniform continuity of altitude distribution through all altitude classes; the several modes are not very meaningful in this instance (for example, unit-5 of Mount Logan map-area: see histogram, figure B-1 of appendix-B). But even when the sample is large, the modal tendency may be not too well defined (for example, unit 3-6 of the Big Berry Mtns.

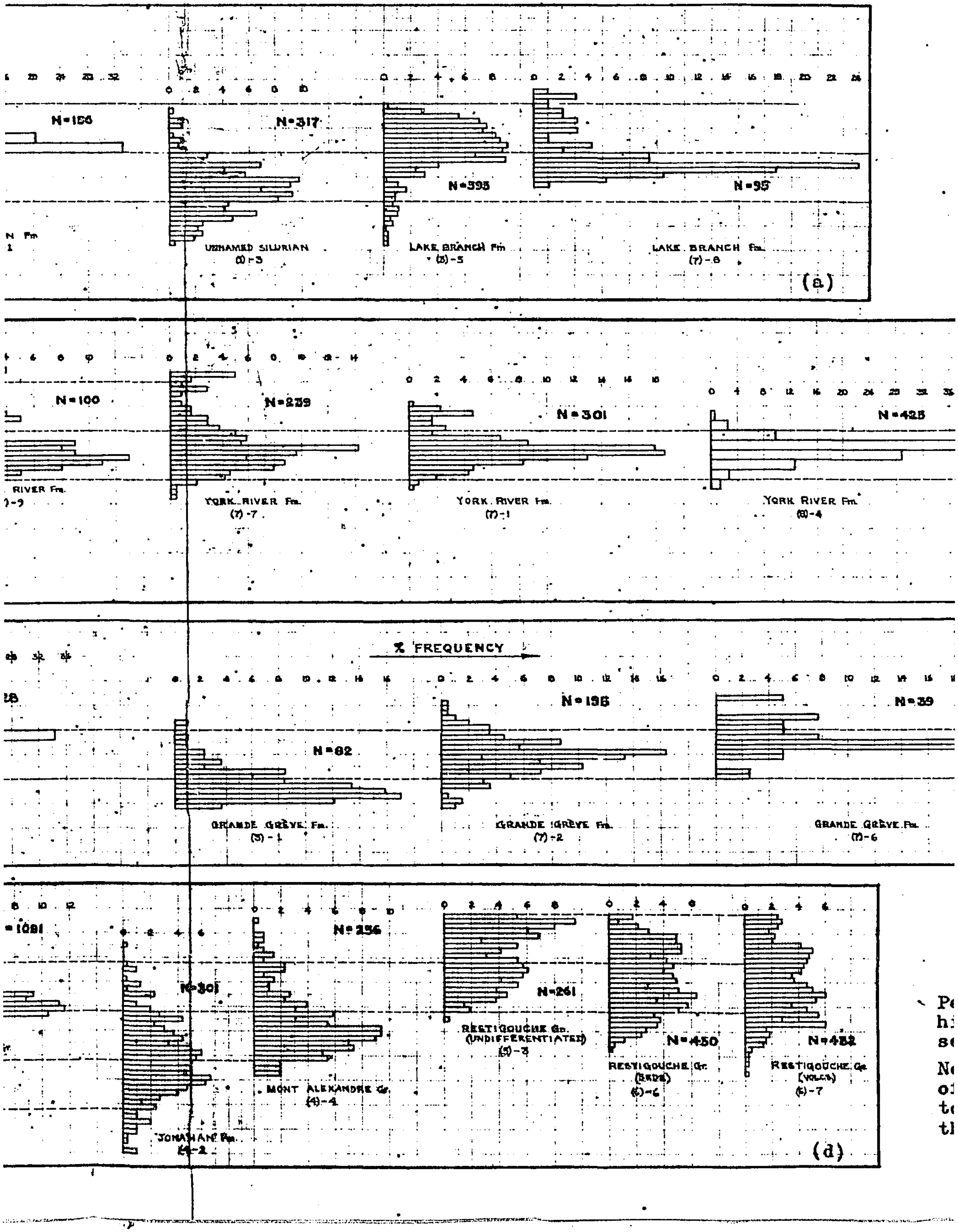
West area: map-3). When there is some difficulty in assigning the limits of a modal tendency (for example, for unit-5 of the Rivière Angers map-area: see histogram 4-5, figure 11a, p. 62), the altitude frequency distribution may be considered in terms of doubled class intervals - 100 ft classes in this case. The modal tendency usually becomes much more evident.

In general, polymodal altitude distributions should signal the presence of mixed subpopulations within the sample. These may be due to special causes: such as glaciation, in the case of the Tabletop granite area (map-2; refer to histograms 2, 2A, 2B of figure B-2, appendix-B); or faulting, as in the Oak Bay area (map-6; see histograms 6, 7, 6A, 6B, 7A, 7B of figure B-6, appendix-B); or mixed rock formations, i.e., the presence of lithology other than that mapped for the area.

More commonly, polymodal altitude distributions indicate mixed subpopulations attributable to the general form-facets of the topography - upland, slope and lowland. For example, in the Rivière Angers map-area, the Fortin Group (unit-3) supports an altitude frequency distribution with three modes. (See histogram 4-3, figure B-4, appendix-B). The primary or dominant modal tendency is at 1300-1700 ft altitude and represents the gently rolling upland, found in the area; the mode at 200-250 ft correlates with the broad, flat-bottomed Causapscal River valley; and the mode at 650-700 ft represents, approximately, the mid-altitude of the valley side slopes. Similarly, in the Cuoq map-area (map-8), the St. Leon formation has two modes: the higher correlates with the altitude of the upland surface, and the lower represents the valley floor of the Matane River (refer to histogram 1, figure B-8, appendix-B). In the Causapscal East area (map-7), the York River formation (unit-9) has a well-defined major mode which correlates with the upland, and minor modes which correlate with slope-facets and the valley bottom of the Cascapedia River (see histogram 7-9, figure 11b, p. 62).

Frequency distributions of altitude, with a single mode, are obtained for topography in which there is present a flat


ALTITUDE
N=2350
QUEBEC Gr.
(1)-1
N=77
ST LEON Fm.
(7)-4
N=173
ST. LEON Fm
(7)-5
N=156
ST. LEON Fm
(6)-1
% FREQUENCY
N=907
BATTERY POINT Fm.
(3)-6
N=223
YORK RIVER Fm.
(3)-4
N=46
YORK RIVER Fm.
(3)-7
N=59
YORK RIVER Fm.
(4)-1
N=100
YORK RIVER Fm.
(7)-9
N=89
CAPE BON AMI Fm.
(1)-4
N=383
CAPE BON AMI Fm.
(7)-3
N=328
CAPE BON AMI Fm.
(6)-2
N=439
HONORAT Gr.
(4)-6
N=548
HONORAT Gr.
(5)-1
N=145
MATAPEDIA Gr.
(4)-5
N=491
MATAPEDIA Gr.
(5)-2
N=1091
MATAPEDIA Gr.
(6)-5



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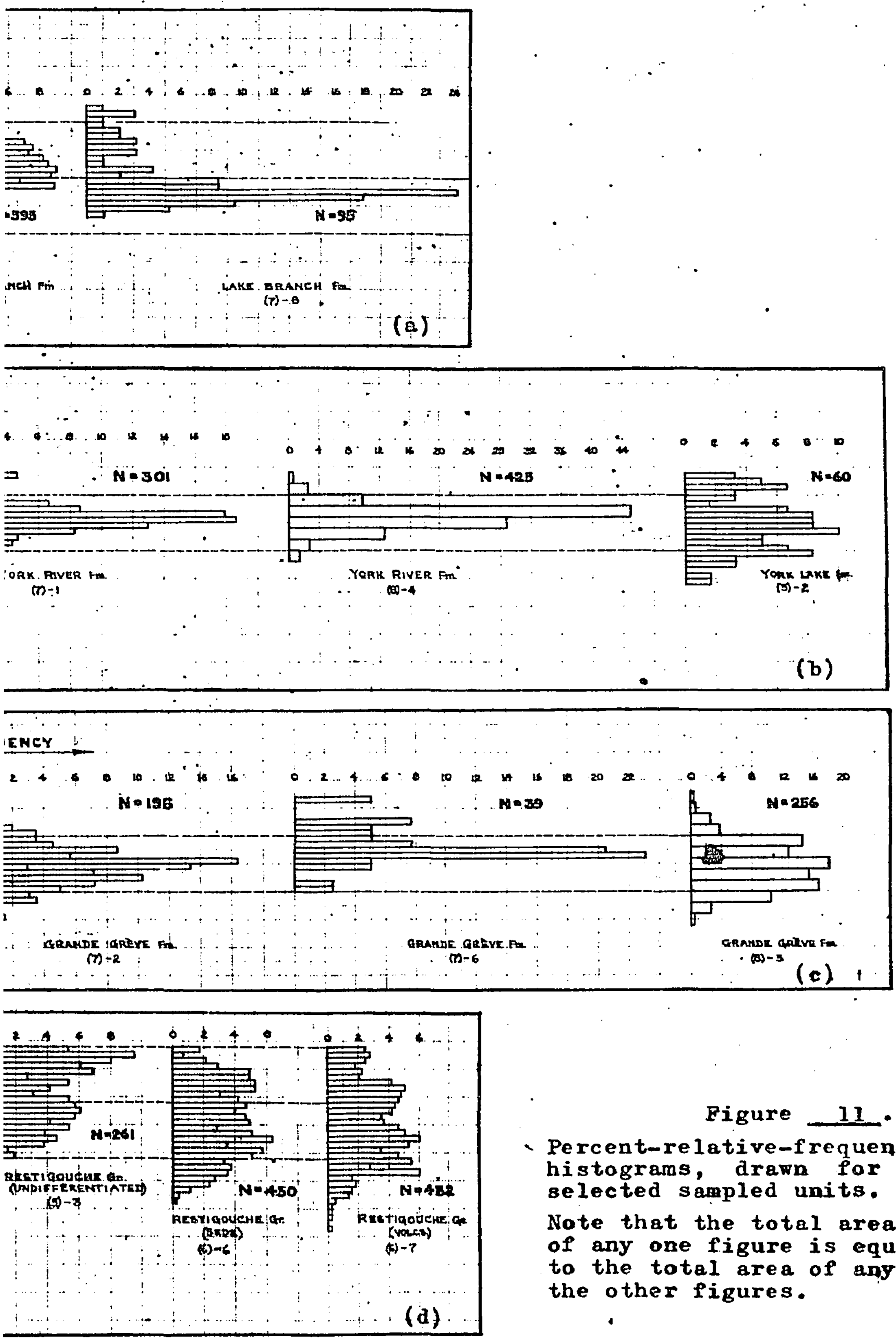

Figure 11.

Percent-relative-frequency histograms, drawn for selected sampled units.

Note that the total area of any one figure is equal to the total area of any of the other figures.

area, such as an upland surface which has not been dissected too greatly; or perhaps a lowland near sea level; or a broad valley flat. The greater the extent of such an area, the better developed will be the modal tendency of its altitude population. In western Gaspé, units 1-4, 3-1, 8-2 and 8-4 (maps 1, 3 and 8, respectively) show well-defined, gently rolling upland surfaces. Histograms of altitude frequency distributions for these units, show clearly defined unimodal character.

For a highly dissected topography ("mature" in the Davisian sense), the modal tendency is still found to occur for the frequency distribution of altitudes. For example, the Jonathan formation in the Rivière Angers East map-area supports a topography made up essentially of slopes. The sample of its altitude population shows a relatively well-developed modal tendency (refer to histogram 4-2, figure 11d, p. 62), which correlates approximately with the altitude locus of the middle part of the slopes (refer to map-4). Theoretically, it is the middle part of slopes which has the greatest areal extent, in a topography in which upland and lowland are at a minimum, i.e., in a "maturely" dissected topography. For the above unit, it is found that the mode, mean and median altitude values are almost equal - the condition necessary for a Gaussian "normal" distribution.

Generally, a frequency distribution becomes smoother as the number of counts in the sample increases. This may be a disadvantage in the case of altitude frequency distributions, derived on the basis of lithology, for it results in the masking of the modes of subpopulations due to form-facets. The distribution obtained for the Quebec group (unit-1 of map-1) is an example. With a total of 2350 altitude counts, its histogram shows an extremely smooth distribution (histogram 1-1, figure 11a, p. 62) with a single mode. The mode(s) representing valley bottom lowlands, which are seen to be present on map-1, are completely masked. In this instance, it would have been better to have divided the area into several parts, and to have counted separate frequency distributions for each.

The mode is dificult to calculate - in the case of polymodal distributions especially, it may be more useful to consider the indications of "modal tendency" instead. The mode does not depend on all altitude values of a distribution (the arithmetic mean does); however, the size of the sample is to some extent critical: very small samples might have no modal tendency; very large samples might have some of the minor modes obscured.

c) The median altitude:

The median measure of central tendency of a distribution of altitudes is of lesser importance than the arithmetic mean or the mode. It is based on the division of the population into two parts: 50% of all altitudes have higher values than the median and 50% have lower values. This indicates that one half of the area sampled lies at a lower level than the median altitude and one half lies at a higher level - but the altitudes within these divisions lie between the limits of the range of altitudes and the median value, and can be in any form of distribution. This provides us with an extremely generalized view of the topography and one which has little meaning.

The median might serve as a preliminary measure of the central tendency. It may be read directly from a plot of cumulative percent frequency and might serve as a rough index for comparison, before the arithmetic mean can be calculated.

3.4-(4) Geomorphic significance of dispersion of altitude parameters:

Dispersion indices measure the spread of values about the central tendency of a distribution. If the grouping is very close about the average of the series, the interpretation is different than when the values have a wide spread. Dispersion of altitudes is an indication of the relief of a topography.

a) The range:

The range is defined as the difference between the lowest and highest altitudes found in an area, and is the simplest index of dispersion. It gives the maximum relief in an area. It is a simple index to derive - its value may be obtained from any contour map. The range, however, is not a very meaningful index, for it is based on two extreme values of a distribution and it does not comment on the arrangement within: the presence of one high hill would produce a large value for the range, but the greater part of the land area could be a featureless plain.

b) <u>The standard deviation from the mean</u>:

As defined and described on page 44, the standard deviation about the arithmetic mean altitude offers a much more significant parameter for the description of topographic relief. It is defined so that a Gaussian "normal" distribution would have 68.26% of all values included within two standard deviations (one on either side of the mean). For moderately skewed distributions, this holds true also. The smaller the value of the standard deviation, the greater the concentration of altitudes about the mean; the less the available relief over the greater part of the land area.

The term "relief" is somewhat confusing in Geomorphic literature. Generally, it is given as the difference between the maximum and minimum altitudes found in an area, i.e., the range; but it is used in discussion as indication of the height of land over which denudational processes due to gravitational shear stresses (Strahler, 1952, p. 924-925) may be considered to act. This is misleading, for most of these processes can be considered only relative to an average value of the relief, and not the total relief, which would not be available over most of the area.

The value of twice the standard deviation about the arithmetic mean altitude would give an index of the "effective" relief of an area, which may be directly related to processes of denudation induced by gravity, considered in terms of average effect.

Values of the range and standard deviation are tabulated in table D-1, appendix-D; the range and "effective" relief are plotted for all rock units in figure 10, p. 56, and grouped in figure 14 , p. 85 .

c) Other measures of dispersion:

Two other measures of the absolute dispersion of values of a frequency distribution were mentioned in section 3.3-(3), p. 44-45. These are: the variance, which is equal to the square of the value of the standard deviation; and the mean deviation, which for moderately skewed distributions, is empirically equal to four-fifths of the value of the standard deviation. These measures do not appear to have much use in describing a topography.

A measure of "relative dispersion", the coefficient of variation, relates the arithmetic mean altitude and the standard deviation by the equation $V = \frac{S}{\bar{X}}$, where V is the coefficient of variation. (The value may be stated as a number or as a percentage.). The coefficient was calculated for all sampled sedimentary rock units and the values were plotted against approximate average distance[3] from the sea (base level). The relationship is shown in figure 12, p. 68.(An exponential trend is obtained, with values of V decreasing with distance measured away from the base level). For rock units which are at a distance greater than about 20 Kilometers from the sea, the values of V are found to be in a relatively narrow range, from about 10 to 30% (standard deviation is 10-30% of mean); the trend is remarkably constant and decreasing very slightly away from sea level. Less than 20 Km from the sea, the rock units support topographies for which the coefficient of variation is much higher, ranging up to a value of 0.65 (65%).

---

3 - The distance from the sea (base level) was obtained by measuring along the major streams, from the sea to the approximate (estimated) "centre of erosion" of the unit. Where several streams drained an area, distances along all were measured and averaged to give the mean distance. All distances are approximate.

Figure 12 shows that in western Gaspé, the standard deviation relative to the mean of altitude populations developed on lithologically similar unit-areas (the relationship may be defined as "relative bedrock dissection") is greatest for units which are closest to the sea (base level). It is interesting to note that there may be seen a vague indication of a cyclical (modified sinusoidal?) trend for values within the general envelope fitted to the relationship.

The coefficient of variation might provide a convenient and meaningful index for comparison of different erosional topographies which may or may not be from the same general area.

3.4-(5) Geomorphic meaning of skewness and kurtosis.

a) Skewness:

Skewness is a measure of the asymmetry of a frequency distribution. It shows the presence of a "tailing" of values (altitude) at either end of the distribution. When the tail is at the upper end, the distribution is said to be positively skewed; when the tailing is at the lower end, it is said to be negatively skewed.

Positive skewness is not common in the sampled lithologically-based altitude frequency distributions in western Gaspé. It is well defined only for the altitude population (topography) supported by the Lake Branch formation in the Big Berry Mountains map-area (histogram 5, figure B-3, appendix-B). In this area, the poorly-consolidated Lake Branch redbeds are adjacent to the very much more resistant York River feldspathic sandstone on one side and the Battery Point greywacke on the other (the difference in relative resistance to erosion of adjacent units is the maximum found in western Gaspé). As outlined on pages 55-57 there is control exerted by the more resistant lithologies on the topographic development on the less resistant formation. The high value of positive skewness in the altitude distribution is thought to reflect this. Positive skewness is found also in the case of

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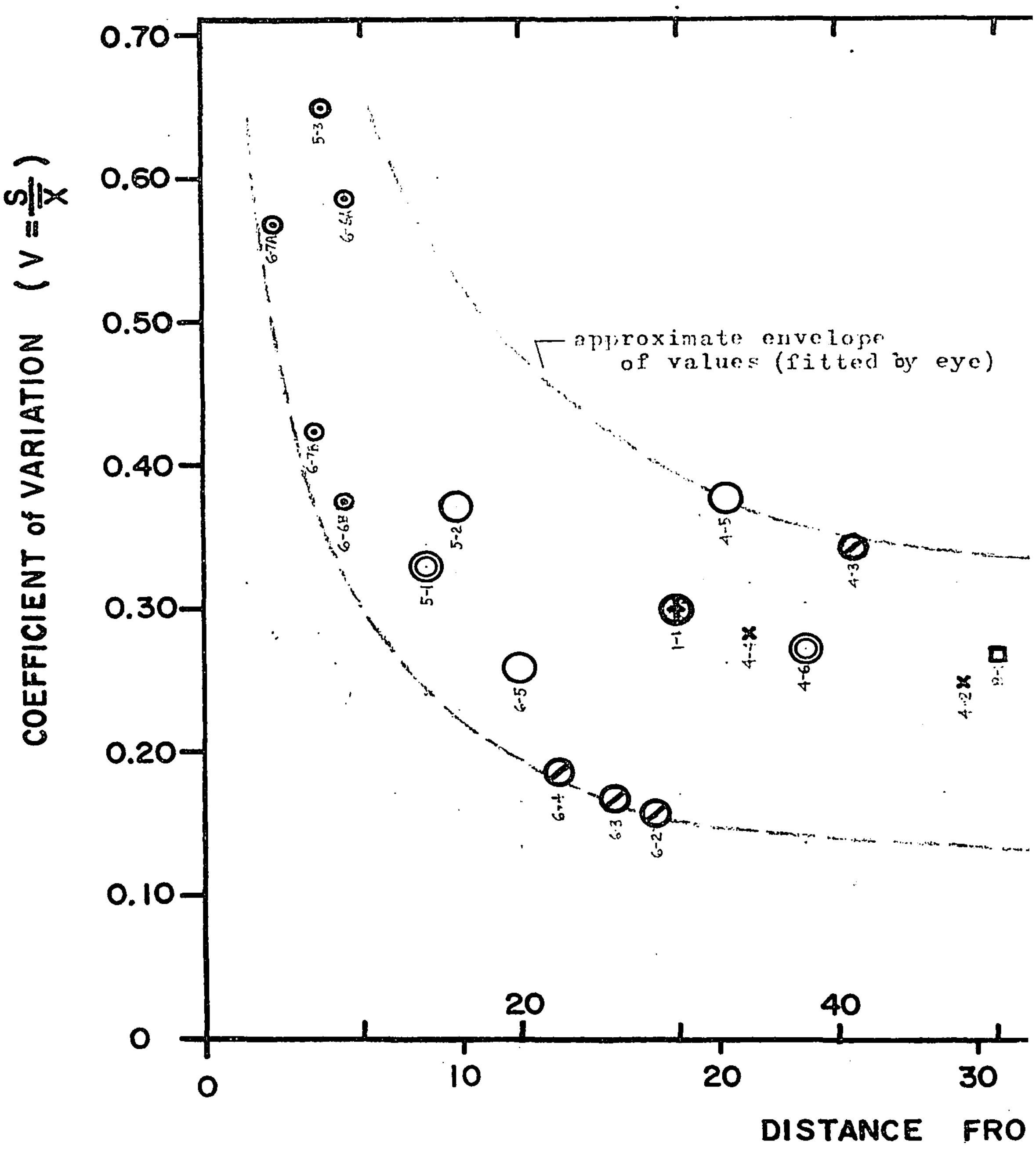
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
COEFFICIENT of VARIATION ($V = \frac{S}{\bar{X}}$)
approximate envelope of values (fitted by eye)
5-3
6-7A
6-5A
6-7B
6-6B
5-1
5-2
6-5
6-4
6-3
6-2
1-1
4-4
4-5
4-3
4-6
4-2
20
40
0
10
20
30
DISTANCE FRO

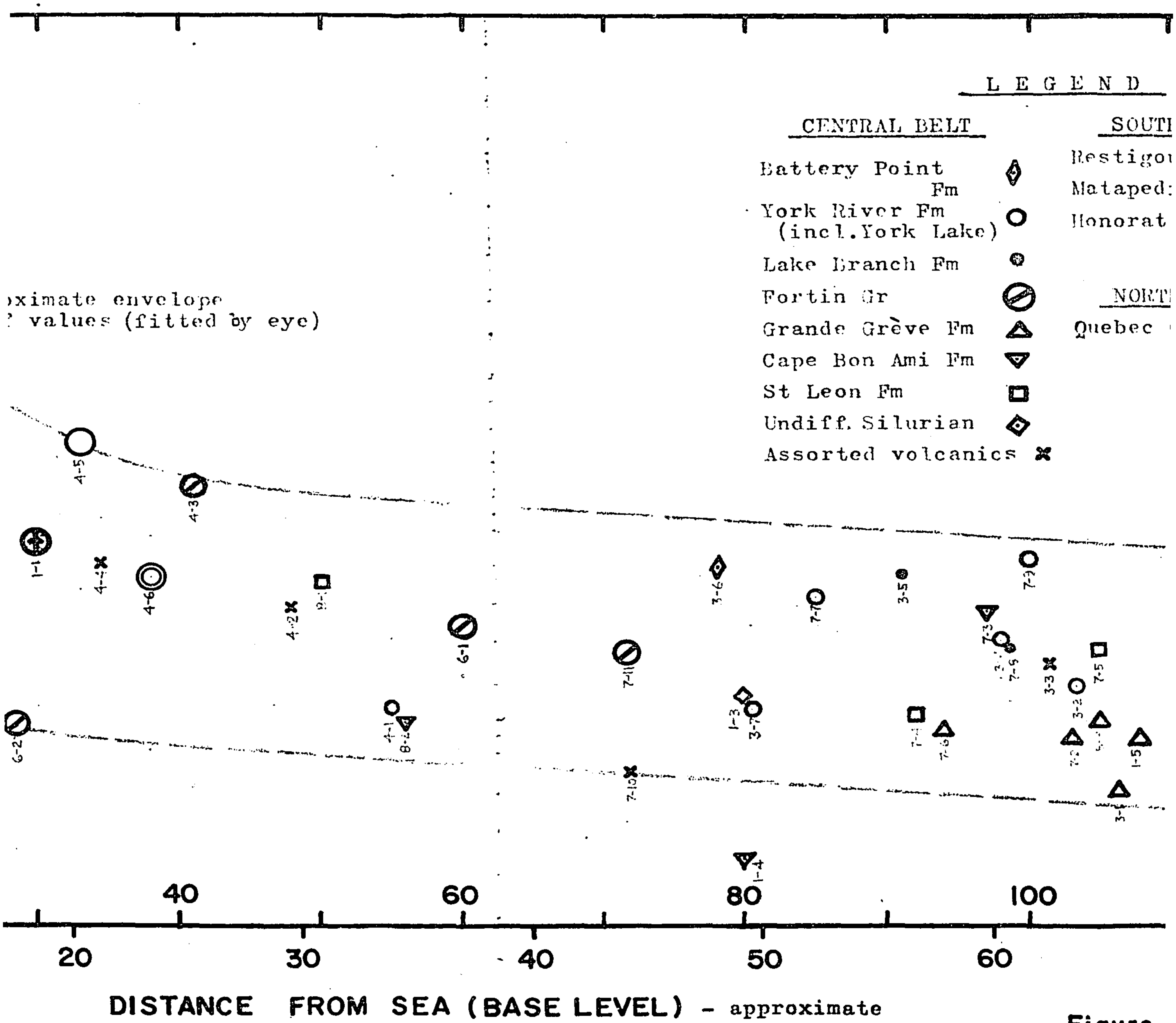
LEGEND
CENTRAL BELT
Battery Point Fm
York River Fm (incl. York Lake)
Lake Branch Fm
Fortin Gr
Grande Grève Fm
Cape Bon Ami Fm
St Leon Fm
Undiff. Silurian
Assorted volcanics
SOUTH
Restigou
Matapedi
Honorat
NORTH
Quebec
ximate envelope
values (fitted by eye)
4-5
4-3
1-1
4-4
4-6
6-1
4-2
6-1
6-2
4-1
8-4
7-11
7-10
3-6
1-3
3-7
7-7
3-5
7-4
7-6
7-3
7-9
7-9
3-3
3-2
7-5
7-2
1-5
3-1
1-4
40
60
80
100
20
30
40
50
60
DISTANCE FROM SEA (BASE LEVEL) - approximate

Figure.

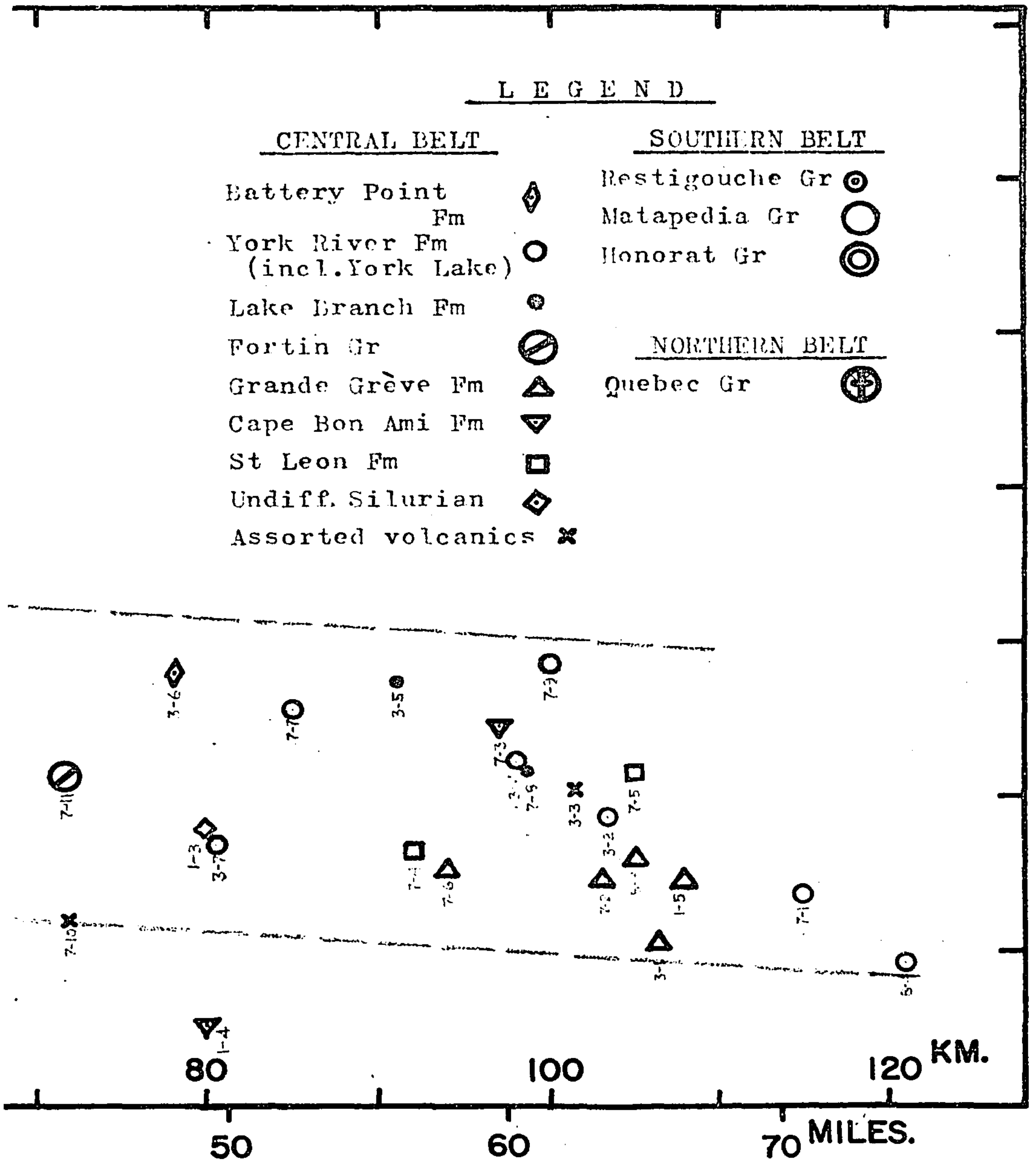

Figure 12. — Plot of Relative Dispersion of altitude (Coefficient of Variation) vs approximate average distance from the sea (Base Level) of rock units.

units 1-5, 5-3, 6-6A, 8-4, 3-4 and 3-6. Except 5-3 and 6-6A, which are very probably affected by structure (faults), all these are adjacent to more resistant lithologies. Positive skewness, therefore, would seem to be a signal of control exerted on altitude distributions by nearby more resistant rock units. Where several border on a relatively nonresistant unit, the controls are superimposed and complex in the overall effect. However, if the area of the weaker rock type is large, the effects due to the adjacent resistant units might be confined to the edges and could possibly be studied by stratified sampling in strips of topography parallel to the unit boundaries.

Since most rock units in western Gaspé do not support positive skewed altitude distributions, it is considered that control by adjacent resistant rock units is not overly important.

Negatively skewed altitude distributions are probably due to the effect of streams. Very high values of negative skewness are correlatable to areas where there is much evident control by major streams acting as well-developed local base levels. For example, sample units 7-4, 7-7, 7-8, 7-9 and 7-11 have altitude populations with high negative skewness values. These are found in the Causapscal East map-area, bordering on the Matapedia River which runs transverse to the trend of the rock units. The river acts as a major base level and there is indication of a regional slope towards it. Units 4-3 and 4-6 similarly have high negative skewness values. These are found in the Rivière Angers East map-area, where the Causapscal River and the Rivière Angers flow through. Again, there are very apparent regional slopes of topography toward these major streams, suggesting the grading of topography. Other examples can be given, and it seems fairly certain that negative skewness indicates a degree of stream erosion.

As found for sediments (Friedman, 1961, p. 524), skewness seems to be environment-sensitive for frequency distributions of topographic altitude also.

b) Kurtosis:

Kurtosis is a measure of the "peakedness" of a frequency distribution curve. It indicates the degree of central sorting.

High values of kurtosis (leptokurtic curves) are obtained for frequency distributions of altitude which correlate with relatively flat or featureless topography: e.g., gently rolling uplands, plains areas, and wide valley flats. The Gaussian "normal" (mesokurtic) distribution, for which the kurtosis value is 3.0, correlates with maturely dissected topography in which slopes dominate and upland and valley-bottom lowland areas are at a minimum. Units 4-2, 4-3 and 4-6 of the Rivière Angers East map-area and units 6-4 and 6-5 of the Oak Bay map-area are examples of topography with mesokurtic altitude frequency distributions. Unit 1-4 in the Mount Logan map-area has an extremely leptokurtic altitude frequency distribution.

Frequency distributions of altitude with low values of kurtosis (platykurtic curves) are found to correlate with topography in which neither well-developed uplands or other extensive flat area, nor mature dissection, is found to be present. Examples would be units 3-4, 3-6, 5-3 and 1-5. The platykurtic distribution probably signifies an intermediate stage of topographic development in the Gaspé.

On the whole, kurtosis comments on the degree of development of the type of landforms found. It shows whether a topography is made up of flat areas or highly dissected.

3.4-(6) Variability of distribution parameters with distance from base level (the sea).

In order to ascertain whether the descriptive parameters of altitude frequency distributions have a dependency on the distance from the primary base level (the sea), figure 100 was drawn (found included in the pocket at the back of the thesis).

Figure 100 shows skewness, kurtosis, standard deviation and arithmetic mean values for the various altitude populations plotted against the approximate average distance of the units from the sea - the base level - measured along drainage lines, on topographic maps of 1:50,000 scale. All the parameters show definite systematic variability . Mathematically fitted first order linear trend lines, according to the least squares method (outlined in most statistical texts), show the average or mean trend of each. An approximate "envelope" of values has been fitted by eye to each graph, in order to allow some comment on the range of values.

It is apparent that base level does exert a definite and systematic control over the development of topography in western Gaspé.

a) Variability of mean altitude and standard deviation with distance from base level:

Mean altitude values plotted against distance from the sea shows an average trend which is defined by the equation:

$$\bar{X} = 924.7 \text{ ft} + 3.372 \text{ D} \quad , \quad \text{where}$$

$\bar{X}$ is mean altitude, in feet; and D is distance from base level, measured in Kilometers. Most means are found within a well-defined 600 ft wide "envelope", parallel to and centered on the calculated average trend line. The values which do not belong in the envelope are believed controlled by structure, because they are all close to faults. Within the trend envelope, the scatter of values shows three parts with high values of mean altitude spaced more or less evenly along the distance axis, with two intervening localities of low mean altitude. A cyclical trend may be speculated but it does not appear to be of any particular significance. Trends for individual rock types mostly show parallellism with the general linear variability, indicating that most are adjusted to the topographic system (for example, the York River Formation, disregarding the upfaulted beds). There is one exception - the Grande Grève siliceous limestones, which have a well defined trend more at right angles to that of the system. Why this is so is not clear, for the rock type is fairly uniform; it may be that the areas sampled are small and distort the trend with some abnormal values; also, there is structure present in or near the outcrops of this lithology, which again might distort values. Another possibility might be that the topographic system is not completely in equilibrium with all rock units.

If the arithmetic mean altitude is an indicator of relative erodibility, then the "envelope" of values as shown in figure 100-A, may approximately define the maximum amount of differential erosion in western Gaspé, if structure were not present.

Standard deviation plotted against distance from base level has a trend which is defined by the equation;

$$S.D. = 321.6 \text{ ft} - 1.050 D \quad , \quad \text{where}$$

S.D. is standard deviation; and D is distance from base level measured in Kilometers. An envelope of values 200 ft wide encloses all but three of the unit values. Again, the envelope is parallel to and centered on the calculated main trend. The graph shows that the average "effective" relief in western Gaspé is greatest at close to base level and decreases directly as the distance toward the interior region. The envelope defines approximately the maximum amount of relief that can be obtained by the variable bedrock found in the system . The relief is governed both by the energy input into the system, and the resistance offered by the bedrock in dissipating the energy through erosion. Along the available distance from base level, found in the system of topography in the map area, the relief over those rock units which are expected to be resistant or fairly so, is found to be high (e.g., the volcanic rocks; the Battery Point Formation; Honorat Group rocks); however, there are several exceptions to this rule .

b) Variability of skewness and kurtosis values with distance from base level:

The variability of skewness plotted against unit distance from the base level is according to the equation:

$$SK = - 0.5118 + 0.00094\ D \quad , \quad \text{where}$$

SK is skewness; and D is the distance from base level, measured in Kilometers. Skewness is defined also by a flaring envelope of values as shown in figure 100D. The above equation shows that the main trend is almost constant over the available distance of streams flowing in the system. The flaring is centered on the main trend and widens away from base level. The negative value of the average skewness indicates probably that stream erosion is prevalent and important throughout the western Gaspé. The flaring envelope probably indicates that: a)- control exerted by adjacent resistant lithologies is more prevalent in the interior region; and b)- control by local base levels, effected by major streams, also becomes more important away from the primary base level. (Refer back to discussion on skewness, section 3.4-(5), p. 67).

Kurtosis plotted against distance from base level has a trend which is defined by the equation:

$$K = 2.6024 + 0.00735\ D \quad , \quad \text{where}$$

K is the kurtosis; and D the distance from base level, measured in Kilometers. The fitted envelope of values is about 3 kurtosis points wide and is centered at the main trend, with its limits parallel to it. Kurtosis is seen to be almost constant with distance away from base level, as is skewness. There does not seem to be any clearly defined relationship with lithology. Within the envelope, values are oriented in a fashion suggesting a broad 'M'-figure, although this may be an illusion. Kurtosis seems to be dependent on local conditions; it does not seem to be a sensitive parameter.

In summary, there is a clearcut relationship of frequency distribution of altitude descriptive parameters to base level. This is empirical proof that base level exerts a systematic control over the development of topography in the western Gaspé.

The trends define the topographic system present in the Gaspé. The fitted average trend lines define the average topographic conditions in the system; while the indicated envelopes of values show the maximum conditions. Thus, the belt or envelope of mean values shows the highest and lowest possible mean altitude at which a rock may stand at any one distance from base level, according to its internal and external characters which define its relative erodibility within the system. The envelope of standard deviation values shows the greatest and least possible relief values that a rock unit might arrive at, depending on its location within the system, as defined by the distance along a stream path from it to the sea. The values of skewness indicate that river erosion is dominant in the Gaspé. Kurtosis seems to be the least descriptive parameter and does not avail much information.

CHAPTER IV

DISCUSSION and CONCLUSIONS

4.1 The lithology-altitude relationship.

4.1-(1) The lithologic unit.

The objective of this thesis was stated to be the description of the lithology-altitude relationship in western Gaspé. This was approached through first defining topography as a population of altitudes (sect. 3.2-1, p. 35) and then sampling the altitude frequency distributions over areas of reasonably uniform lithology. It is therefore important to know what the optimum sized unit of lithology might be, for the uniformity of a rock type is relatively dependent on the availability and type of mapping, and there may be considerable choice for some regions. The units should be considered in relation to the degree of homogeneity of the lithology; the size relative to the area considered for analysis; and the size relative to averaging out of the effects of processes over the unit area.

In western Gaspé, geologic mapping is available only at the group[1] or formation[2] level. It appears, from the discussion given below, that these are optimum units of lithology for this type of study.

Magmatic igneous rocks are generally defined by mineralogy alone and are the least variable of possible rock types, in a relative sense. The question of optimum unit size is not pressing, and has been largely resolved by field mapping: usually the size of an intrusion is characteristic and when mineralogical content differs, different units are mapped. Volcanic igneous rocks can be more variable over a unit area: for example, lava beds might be interlayered with tuffs; or

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1, 2 - The formation is the fundamental rock unit of stratigraphy. It is defined as "..a genetic unit formed under essentially uniform conditions or an alternation of conditions.." (American Stratigraphic Code, 1933). A group consists of two or more formations.

a variety of volcanic rocks might be found closely associated with sedimentary beds. It might be possible in some cases to map these as separate units but usually this is not feasible and the rocks are mapped as a group (e.g., Mont Alexandre group). Generally, igneous rock types show least amount of variability within mapped units.

Sedimentary rocks are mapped in the field by groups, formations, members, or in some cases of very detailed mapping, by the smallest whole unit of deposition, the bed. The bed would be expected to have the least variable lithologic composition; yet it might be made up of thin laminae of materials which might have very different resistances to weathering and erosion. Thus, regardless of the type (size) of sedimentary rock unit chosen as the basis of analysis of the lithology-altitude relationship, lithology would never be perfectly homogeneous over any unit area. Furthermore, sedimentary strata or beds have certain inherited orientations in space (dip and strike) which provide for more heterogeneity over unit areas of "uniform" lithology. The bed controls the development of microrelief in a relatively finite area but its effect on overall topography and macrorelief is lost. The member also is a relatively small unit and has an added disadvantage in that it is not commonly used in geologic mapping. Usually, members are designated to outline units of local importance only. The most commonly used unit for geologic mapping is the formation which has the following common characteristics (after Weller, 1960, p. 421-433):

a)- vertical continuity of deposition;
b)- lateral continuity of similar strata;
c)- consistent chemical and mineralogical composition;
d)- abrupt changes of lithology with respect to adjacent formations;
e)- possible presence and persistence of key beds;
f)- possible cyclic repetitions of strata.

Field geologists consider the formation in very broad terms as "...the mappable rock unit..." . Weller (1960, p. 425) comments on this practical view:

> "In order to be practical, a formation should be identifiable and distinguishable from adjacent formations by virtue of reasonably obvious characters that can be recognized by any competent geologist. Most commonly, gross lithologic characters are relied upon although there are numerous exceptions. The ideal formation consists of a single distinctive kind of rock sharply set off from different but equally distinctive rocks both above and below."

These are excellent standards for mapped rock units on which lithology-altitude analysis might be based, at the level at which the entire topographic system of a region is under consideration. Formations are variable in size but they are sufficiently large to allow a good assimilation and averaging of the effects of processes acting to reduce the topography. This is important, for processes over a finite area can be in very poor adjustment with the bedrock and might distort the altitude population considerably from that which might be characteristic for a particular rock type. Also, the formation is thought to be sufficiently large to keep to a minimum the effects of adjacent very resistant units; and there would be little effect of depositional cover derived from other units (problems which might be critical when individual beds are compared). Thus it appears that the formation is the most readily available unit of reasonably similar lithology and the optimum rock unit for this study.

4.1-(2) Relative erodibility in western Gaspé.

a) General comment on relative erodibility:

According to the theoretical basis of this study outlined in section 3.2-(1), points 1-4, on page 35, relative erodibility should be manifest in the distribution and average height of altitude populations supported by the various units of lithology. Some discussion will be given in this section, of the properties of rocks which determine their individual erodibilities.

The nature of this study precludes detailed review of processes which contribute to the lowering of a land mass.

A general framework is envisioned as that given by Strahler in his outline of the dynamic basis of geomorphology (Strahler, 1952). Briefly, it is considered that earth materials are affected or acted upon by a variety of natural processes which exert shear stresses to produce strains which cause failure. Weathering, erosion, and mass wasting are all explained in this way. For background, Leopold, Wolman and Miller (1964, p. 27-130) provide more general discussion.

Since the rock units are all from the same area, climate in this study is considered a constant variable. Thus processes which are all dependent on climate are acting more or less equally on all rock units, and the focus is on the response of the various rocks in resisting the effects which tend to wear them down. The resistance of rock units at the formation level should depend on the following properties:

a)- the nature of the internal fabric (texture) of the major constituent rock type of an area (mineralogy, granularity, cementing, degree of consolidation and metamorphosis);

b)- the nature of the external features(structure) of the rocks (bedding, cleavage, jointing, schistosity; faults and folds);

c)- the degree of variable lithology within the formation (uniform, interbedded, cyclically bedded formations; grouped formations);

d)- exterior controls and controls due to adjacent very-resistant ("ridge-making") rock formations.

In addition to the above, in western Gaspé there is some dependence on distance measured from the rock unit along streams to the primary base level (the sea).

Mineralogy (and crystal size) determines the susceptibility of igneous rocks to weathering. The rock forming silicate minerals have a definite order of susceptibility which is in accordance with Bowen's[3] reaction series, as shown by figure 13, below:

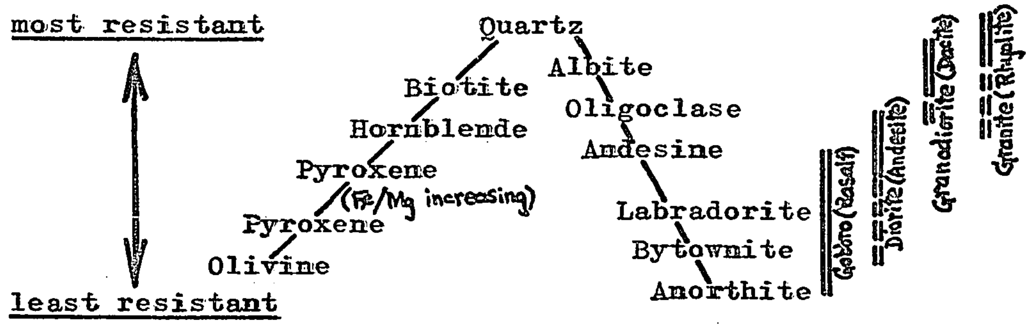

Figure 13 — Bowen's reaction series for common rock forming silicate minerals.

The susceptibility to weathering of sedimentary rocks is determined by the type of mineral grains found present; but also important are the degree of consolidation and the type of cement which bonds the grains. Thus, for example, the most resistant unit might be expected to be one which has a composition made up mostly of quartz grains bonded by a silicate cement; and the least resistant rocks might have mostly clay minerals which are easily erodible when aggregated, and with a calcium carbonate cement.

The nature of the external features (structure) of rock units governs erodibility in a secondary sense. Weathering may proceed along joint planes and erosion is enhanced by a well developed cleavage, schistosity, or closely spaced joints. Bedding orientation in the ideal case should be vertical for all units, for then the characteristic resistance of each rock type relative to that of the others would be most clearly shown. In western Gaspé, the units at formation level have a more-or-

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[3] — Bowen, 1928, The evolution of igneous rocks: Princeton Univ. Press, Princeton, N.J., (reprinted by Dover Publ., N.Y., 1956).

less uniform strike orientation and considerable variation in the dip of bedding. Qualitatively, it may be stated that the dip variability is approximately of the same order for most formation and group units.

It is important to consider the presence and amount of lithologic variability within a formation. Most such rock units are never entirely homogeneous. For example, the Battery Point formation is mainly greywacke sandstone but it is also up to about 20% interbedded shale (estimate by Carbonneau, 1959, p. 37). The York River formation is mainly feldspathic sandstone but can have up to about 35% interbedded shale and fine grained siltstone (Carbonneau, 1953, p. 183). The other formations in western Gaspé all have some variability with regard to lithology but for most there are no %-composition estimates available.

Effects due to adjacent resistant formations do not appear to be important for formation and group units in western Gaspé.

b) Relative erodibility of rocks mapped as formations in western Gaspé:

There are several fairly distinct rock types found in western Gaspé Peninsula. In order to consider their relative erodibility, they were grouped by broad categories of sedimentary, volcanic, and igneous types; sedimentary rocks were then subdivided further into calcareous and detrital classes, while volcanic and igneous rocks are considered by individual units. The sedimentary rocks, which are the most abundant category, have a variety of subtypes. Table 3, page 81, shows the breakdown.

From the theoretical considerations advanced in sections 3.2-(1) and 3.4-(3) it seems that the lithology-altitude system avails a simple but useful index on which to base the consideration of relative erodibility. This is the arithmetic mean altitude.

LITHOLOGIC TYPE	MAP SHEET-and-UNIT number
<u>SEDIMENTARY ROCKS:</u>	
(a)- <u>Calcareous rocks.</u>	
GRANDE GREVE siliceous limestones	(1)-5, (3)-1, (7)-2, (7)=6, (8)-3.
CAPE BON AMI argillaceous limestones	(7)-3, (8)-2, (1)-4..?.
ST. LEON calcareous siltstones	(7)-4, (7)-5, (8)-1.
Undifferentiated Silurian	(1)-3.
YORK LAKE calcareous siltstones	(3)-2.
Matapedia Group argillaceous limestones	(4)-5, (5)-2, (6)-5.
FORTIN Group calcareous shale fac.	(6)-1, (6)-3.
FORTIN Group calcareous slate	(7)-11.
(b)- <u>Detrital rocks.</u>	
BATTERY POINT greywacke sandstones	(3)-6.
YORK RIVER feldspathic sandstones	(3)-4, (3)-7, (4)-1, (7)-1, (7)-7, (7)-9, (8)-4, (3)-2*.
HONORAT Group mudstones	(4)-6, (5)-1.
ST. LEON (calcareous) siltstones	(7)-4*, (7)-5*, (8)-1*.
LAKE BRANCH redbeds	(3)-5, (7)-8.
FORTIN Group sandstone fac. (grits)	(6)-2.
FORTIN Group (calcareous) shale fac.	(6)-1*, (6)-3*, (7)-11*.
FORTIN Group siltstone fac.	(6)-4.
RESTIGOUCHE Group mudstones	(6)-6.
QUEBEC GROUP (mainly slates and shales)	(1)-1

HONORAT Group mudstones	(4)-6, (5)-1.
ST. LEON (calcareous) siltstones	(7)-4*, (7)-5*, (8)-1*.
LAKE BRANCH redbeds	(3)-5, (7)-8.
FORTIN Group sandstone fac. (grits)	(6)-2.
FORTIN Group (calcareous) shale fac.	(6)-1*, (6)-3*, (7)-11*.
FORTIN Group siltstone fac.	(6)-4.
RESTIGOUCHE Group mudstones	(6)-6.
QUEBEC GROUP (mainly slates and shales)	(1)-1.
VOLCANIC ROCKS:	
STE. MARGUERITE augite andesites	(7)-10.
RESTIGOUCHE Group basic lavas	(6)-7.
JONATHAN amygdaloidal andesites and acidic tuffs	(4)-2.
MONT ALEXANDRE Group basic lavas with siltstones	(4)-4.
Unnamed Devonian diabasic rocks	(3)-3.
SHICKSHOCK Group metamorphosed lavas	(1)-2.
INTRUSIVE ROCKS:	
TABLETOP granite	(2)-2, (2)-2A, (2)-2B.
MONT ALBERT dunite-peridotite	(2)-1.

Table 3 - Sampled units arranged according to similar lithologic type. Note that some units (*) fit more than one category.

The arithmetic mean altitude is a valid indicator of relative erodibility only if the altitude populations for the compared areas of uniform lithologies are in adjustment with the acting denudational processes. The degree of adjustment should be of the same order for all the units which are compared, and thus only units of the same topographic system can be treated.

The Gaspé Peninsula, alike with the general Appalachian region, may be considered after Hack (1960, p. 89) to have a "ridge and ravine" type of topography, for which the "..diversity of form is largely the result of differential erosion of rocks that yield to weathering in different ways." Western Gaspé Peninsula is within a single system of topography, which is described and defined by the figure 100. It is defined, after Hack, as an "erosionally graded topography" with close adjustment of process and form . Thus, all the sampled rock units may be compared as to their relative resistance to being lowered by the acting processes of denudation. Care should be taken in comparing other rock units, even from as close by as eastern Gaspé. It must be shown first that the topographic system is the same; or if different, the difference must be compensated for.

By comparing mean altitude values and the rock textures and structures, the value of the mean altitude as an index of relative erodibility may be checked qualitatively. With this purpose in mind, a bar graph was plotted (figure 14, p. 85), with mean altitude shown for each rock unit, along with other data. For rock types which have several unit samples, weighted means were calculated and also plotted. The formula used is:

$$\overline{X}_w = \frac{N_1\overline{X}_1 - N_2\overline{X}_2 - \ldots\ldots - N_n\overline{X}_n}{N_1 - N_2 - \ldots\ldots - N_n}$$

, where $\overline{X}_w$ is the weighted mean altitude of a rock type with several sample units; $\overline{X}$ is the mean altitude of individual sample units; and N is the number of altitude counts in a sample (an indirect measure of the area of outcrop).

The weighted mean altitude takes into account the overall area of a rock type in western Gaspé and therefore it is a true representational average.

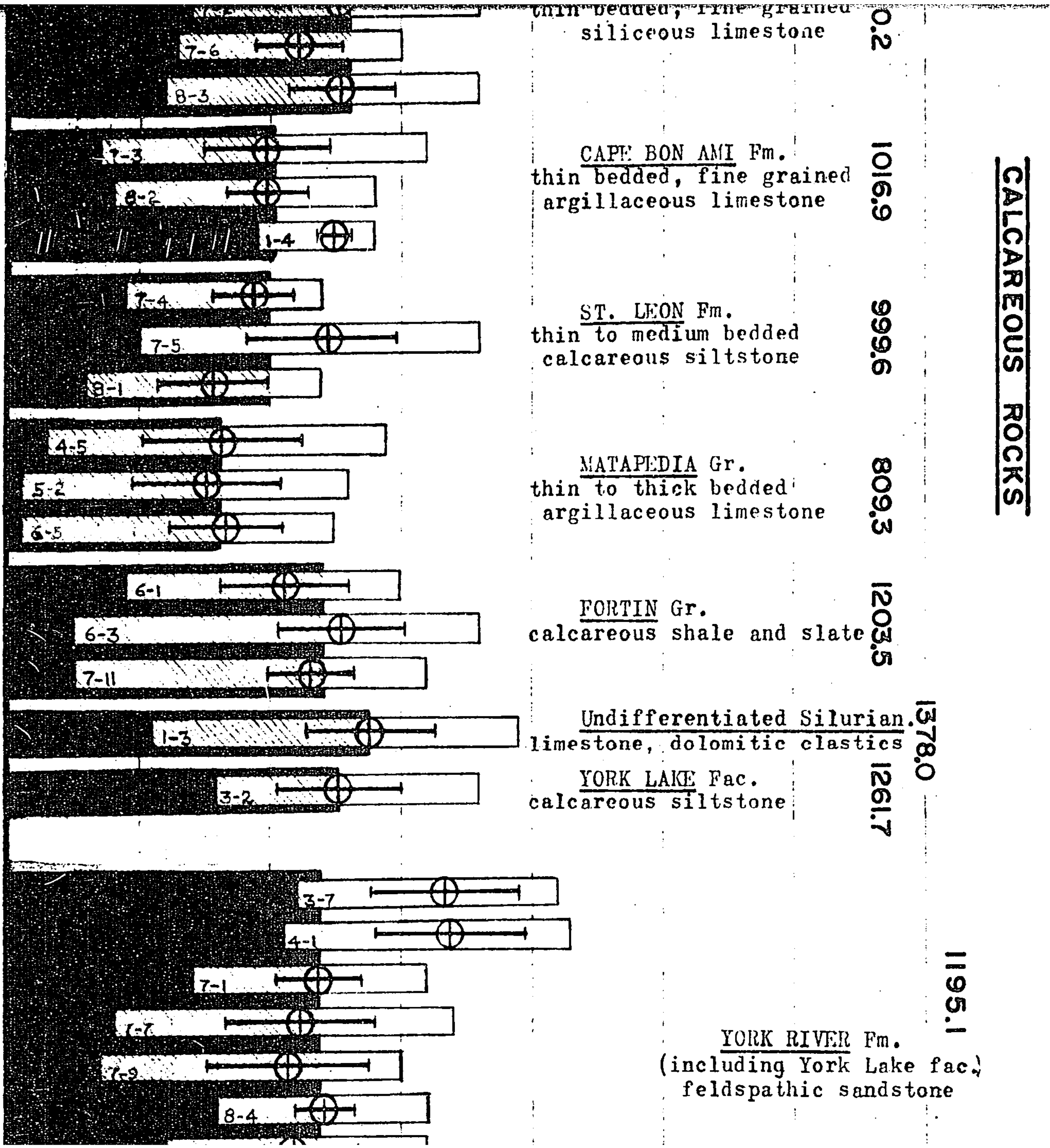
Figure 14, p. 85 shows arithmetic mean altitude, the standard deviation taken twice (the "effective" relief), and the altitude range of each individual unit, arranged according to the broad categories of similar lithology outlined in table 3, p. 81. Some general trends are apparent at once: igneous rocks stand highest; next are volcanic rocks; detrital sedimentary rocks; and calcareous sedimentary rocks. Among the detrital rock types, sandstones stand higher than siltstones and shales; and among the calcareous rocks, dolomitic and siliceous limestones are higher than argillaceous limestones. There appears to be a correlation of arithmetic mean altitude or the mean topographic height with the first precept given on page 78 – the nature of the internal fabric and composition of the main rock type of formation size units. Among the igneous rocks, there is an excellent correlation of mean altitude and mineralogy according to Bowen's reaction series. It is seen that granite stands higher than peridotite, which stands higher than amphibolite schists.

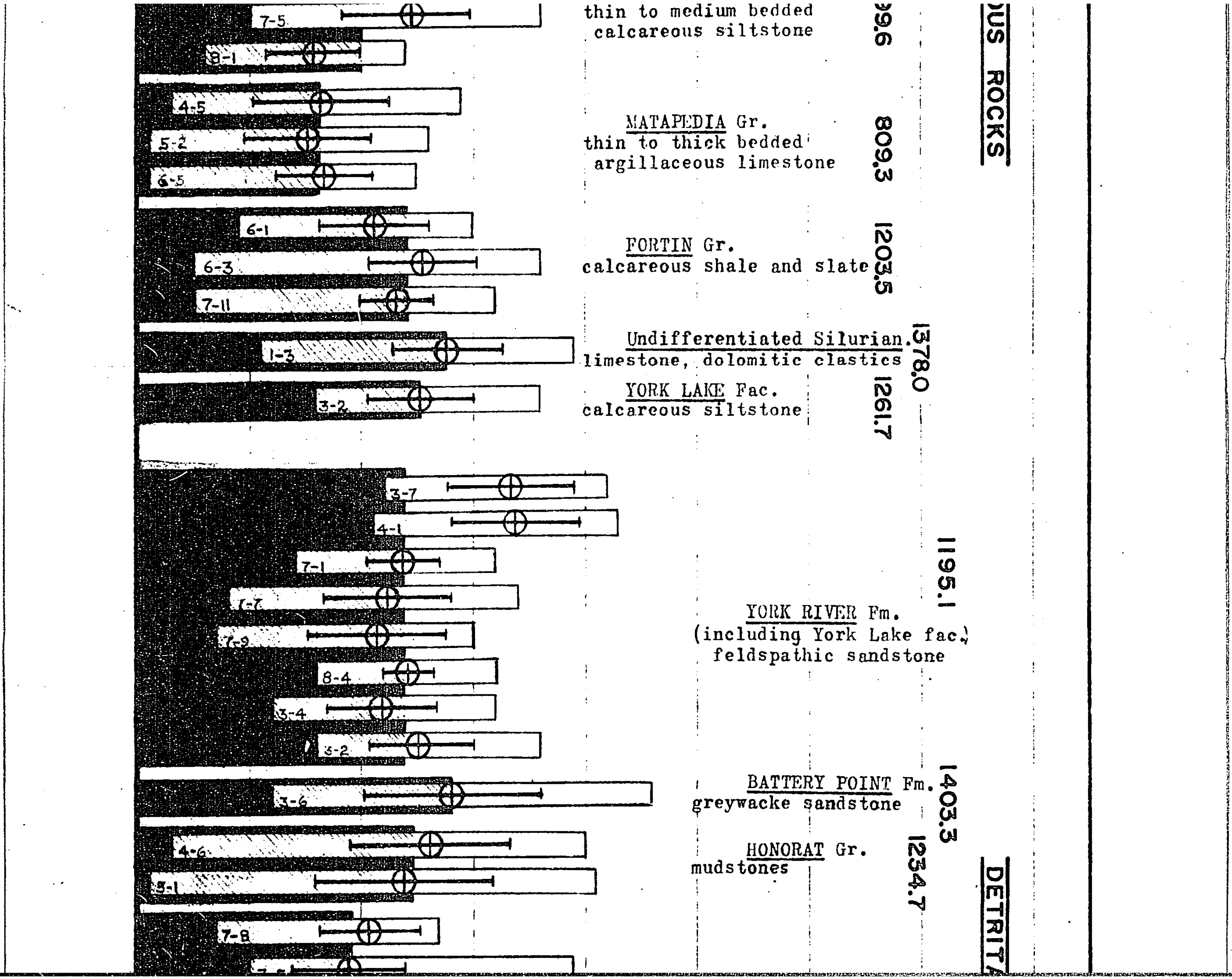
Apart from the consideration of main general trends, the individual units may be compared from the diagram (figure 14) which is fairly self-explanatory. Most mean altitude values are seen to occur within a narrow range, but nevertheless there is a definite order for the various rock units which is tied in with mineralogy and composition of the bedrock.

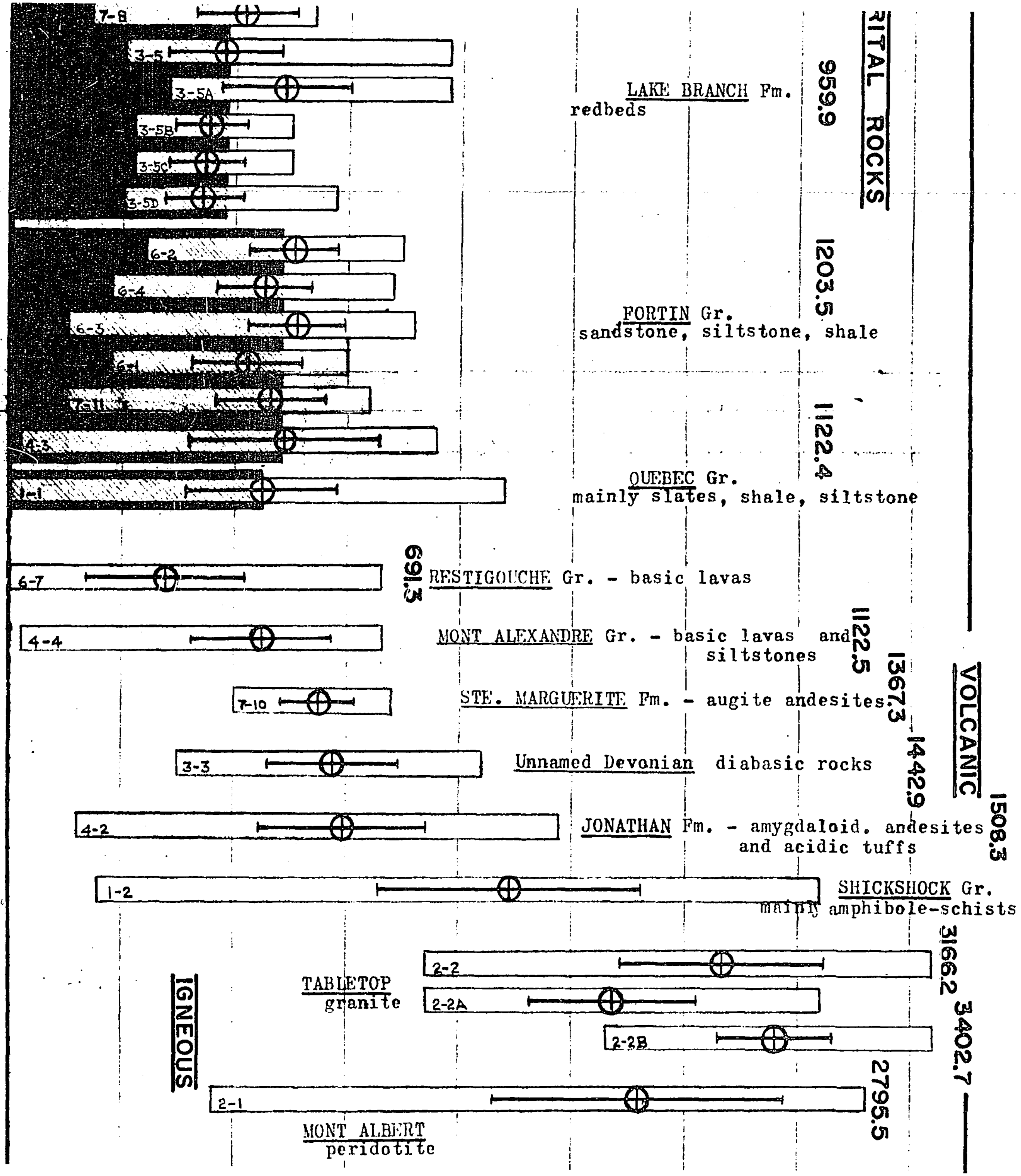
The plot of figure 14 should be compared with that of figure 10, p. 56, which has mean altitudes grouped according to map-areas. Note that there has not been any mention of relative erodibility with respect to land height, in the discussions of these diagrams. These are simply descriptive plots of the land height over various formations. Differential erosion is an inference which, as we shall show, cannot be made directly from the consideration of altitude alone, for altitude is simply land height measured above the arbitrarily chosen datum-plane of the sea. There may be a "datum-plane" imposed by the erosional system in which the rock units are found, and this must be considered.

Within a topographic system, there may be an inherent spatial distribution of land height according to the particular conditions which govern the system. The profiles drawn for figure 3, p.23, suggest a regional slope for western Gaspé, from the interior region to Chaleur Bay. When the descriptive frequency distribution of altitude parameters are plotted against the distance measured along the major streams draining the rock-topographic units to the sea (to base level), the overall topographic system is more clearly revealed. Mean altitude is found to increase linearly from the sea to the interior ; "effective" relief is found to decrease; and skewness and kurtosis also show well-defined trends (also linear). The consideration of relative erodibility, using as index the arithmetic mean altitude of populations developed on various bedrock, must proceed only through first crediting the amount of control this has on the mean.

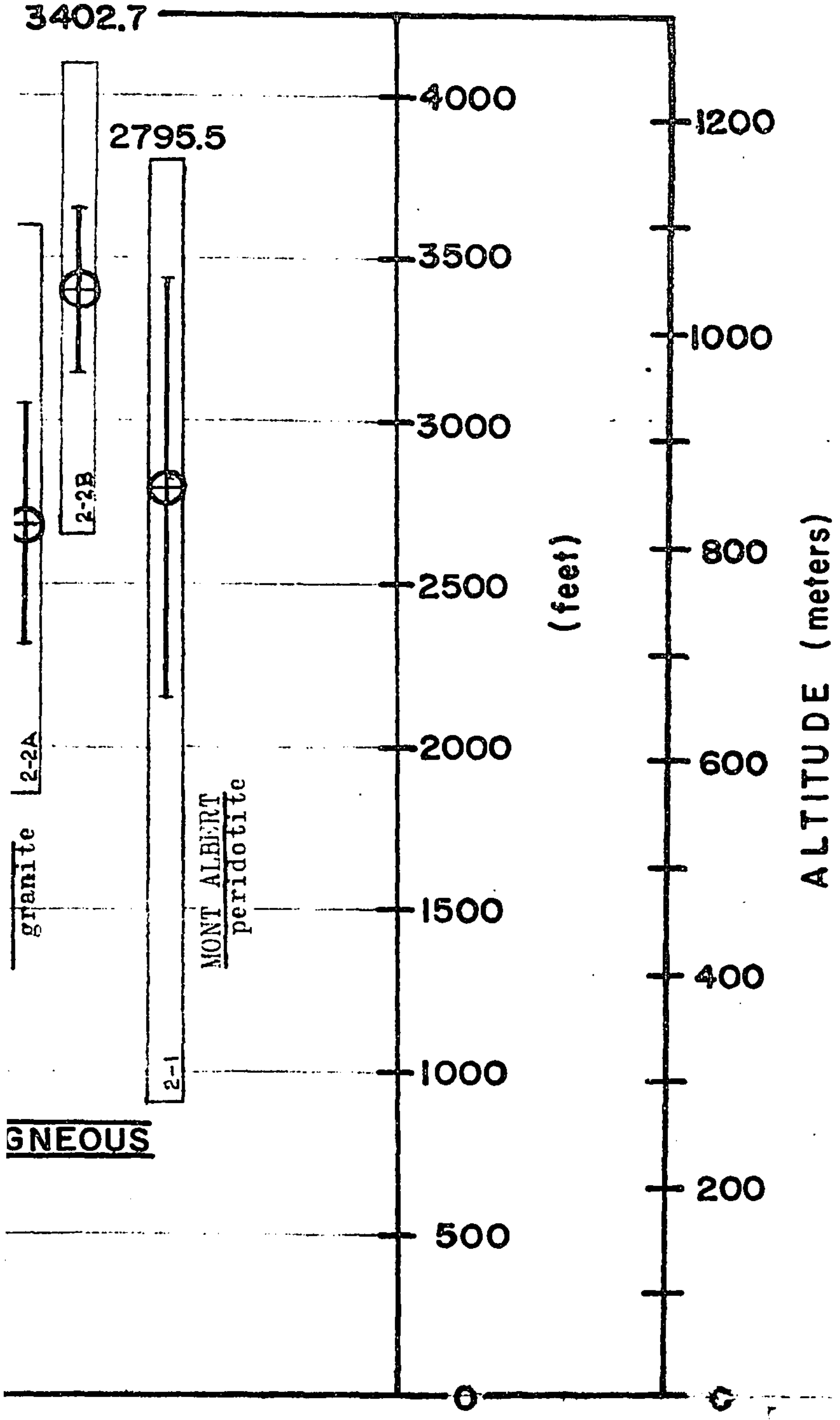
Figure 100A (diagram in back pocket) shows the variation of mean altitude with distance from base level to be linear and such that most values occur within the envelope that is shown. On the basis of this trend, it was considered that a "Relative Erodibility Diagram" could be constructed, as shown by figure 15, p. 88. The diagram is a plot of the weighted average mean altitude values (calculated from the means of all samples of a particular rock type, taking into account the relative size of each unit) -versus- the weighted average distance from base level. The formulae used are those given on the diagram on page 88, and in the discussion on page 82. The effect of position within the system, with respect to base level, can then be removed from each unit. This can be done graphically by projecting the loci that are plotted for


CALCAREOUS ROCKS
thin bedded, fine grained
siliceous limestone
0.2
7-6
8-3
CAPE BON AMI Fm.
thin bedded, fine grained
argillaceous limestone
1016.9
7-3
8-2
1-4
ST. LEON Fm.
thin to medium bedded
calcareous siltstone
999.6
7-4
7-5
8-1
MATAPEDIA Gr.
thin to thick bedded
argillaceous limestone
809.3
4-5
5-2
6-5
FORTIN Gr.
calcareous shale and slate
1203.5
6-1
6-3
7-11
Undifferentiated Silurian.
limestone, dolomitic clastics
1378.0
1-3
YORK LAKE Fac.
calcareous siltstone
1261.7
3-2
YORK RIVER Fm.
(including York Lake fac.)
feldspathic sandstone
1195.1
3-7
4-1
7-1
7-7
7-9
8-4


7-5
8-1
4-5
5-2
6-5
6-1
6-3
7-11
1-3
3-2
3-7
4-1
7-1
7-7
7-9
8-4
3-4
3-2
3-6
4-6
5-1
7-8
thin to medium bedded
calcareous siltstone
99.6
MATAPEDIA Gr.
thin to thick bedded
argillaceous limestone
809.3
FORTIN Gr.
calcareous shale and slate
1203.5
Undifferentiated Silurian.
limestone, dolomitic clastics
1378.0
YORK LAKE Fac.
calcareous siltstone
1261.7
1195.1
YORK RIVER Fm.
(including York Lake fac.)
feldspathic sandstone
BATTERY POINT Fm.
greywacke sandstone
1403.3
HONORAT Gr.
mudstones
1234.7
US ROCKS
DETRIT



7-8
3-5
3-5A
3-5B
3-5C
3-5D
RITAL ROCKS
959.9
LAKE BRANCH Fm.
redbeds
6-2
6-4
6-3
1203.5
FORTIN Gr.
sandstone, siltstone, shale
4-3
1-1
1122.4
QUEBEC Gr.
mainly slates, shale, siltstone
6-7
691.3
RESTIGOUCHE Gr. - basic lavas
4-4
MONT ALEXANDRE Gr. - basic lavas and siltstones
1122.5
7-10
STE. MARGUERITE Fm. - augite andesites
1367.3
3-3
Unnamed Devonian diabasic rocks
1442.9
VOLCANIC
4-2
JONATHAN Fm. - amygdaloid, andesites and acidic tuffs
1508.3
1-2
SHICKSHOCK Gr.
mainly amphibole-schists
2-2
3166.2
TABLETOP
granite
2-2A
3402.7
2-2B
IGNEOUS
2-1
2795.5
MONT ALBERT
peridotite



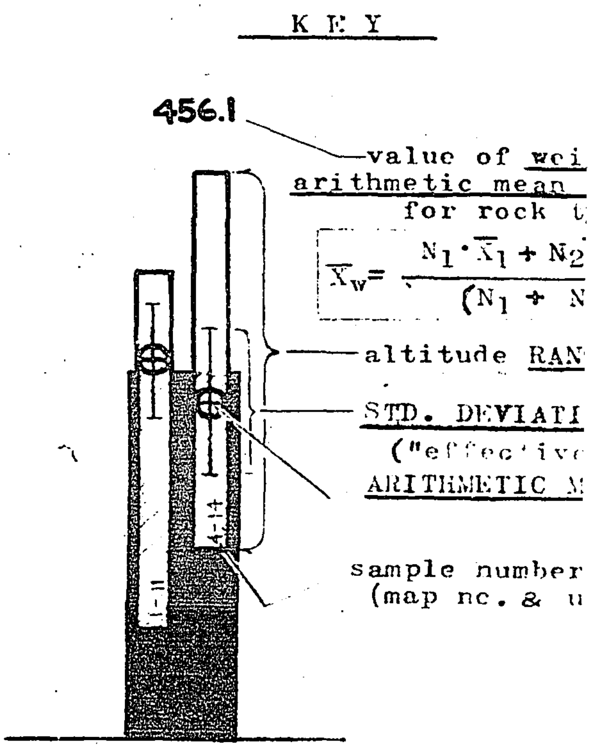
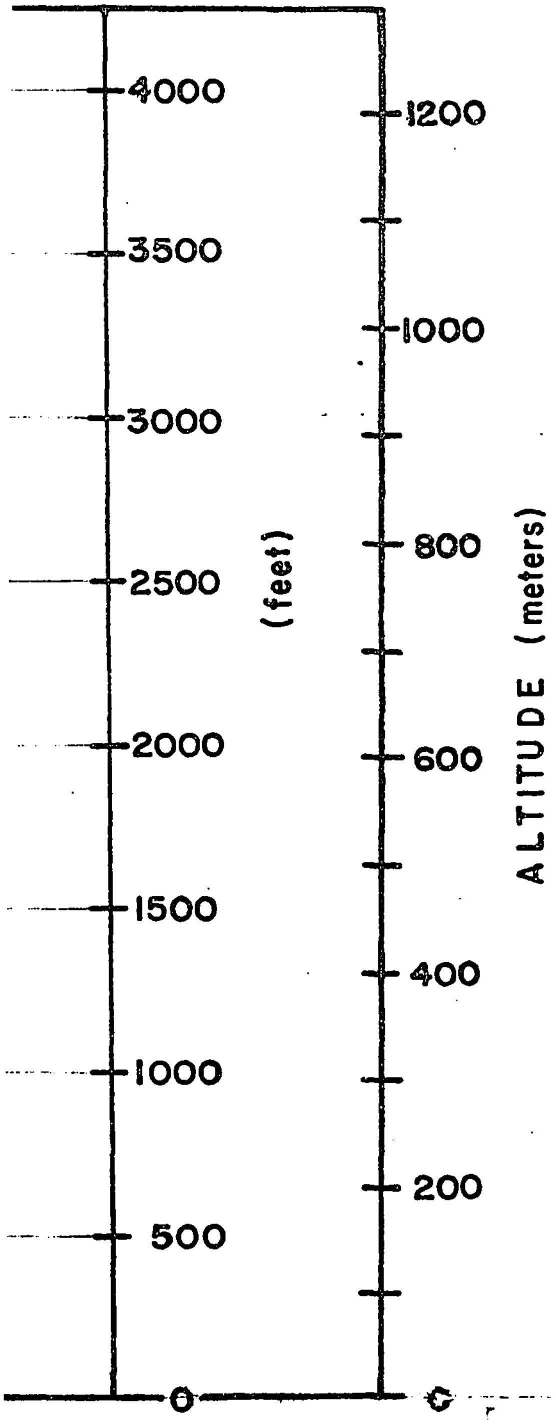


Figure 14.- Plot of Arithme Mean Altitude, Standa Deviation, and Range, units arranged accord to similar lithology.



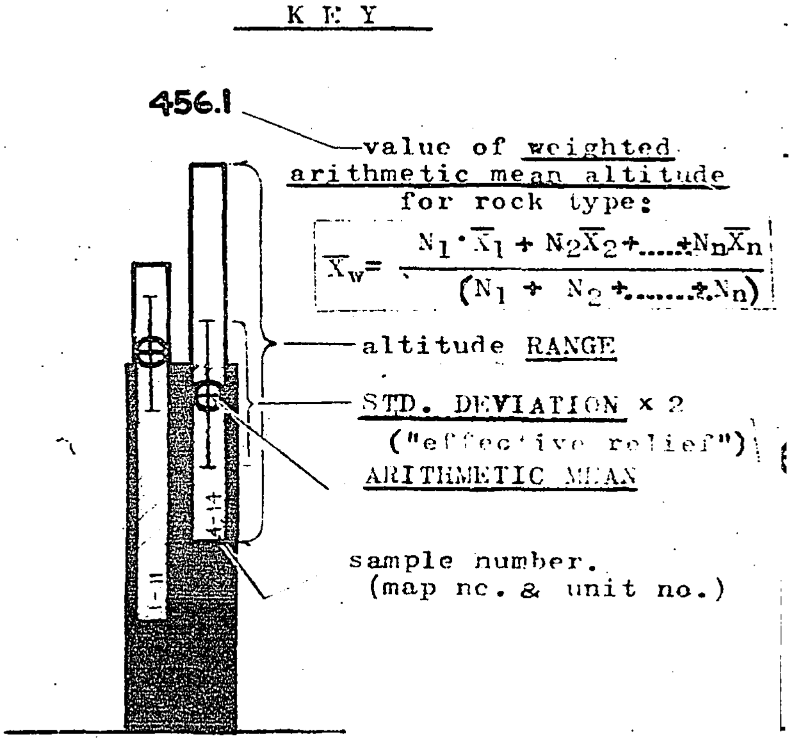
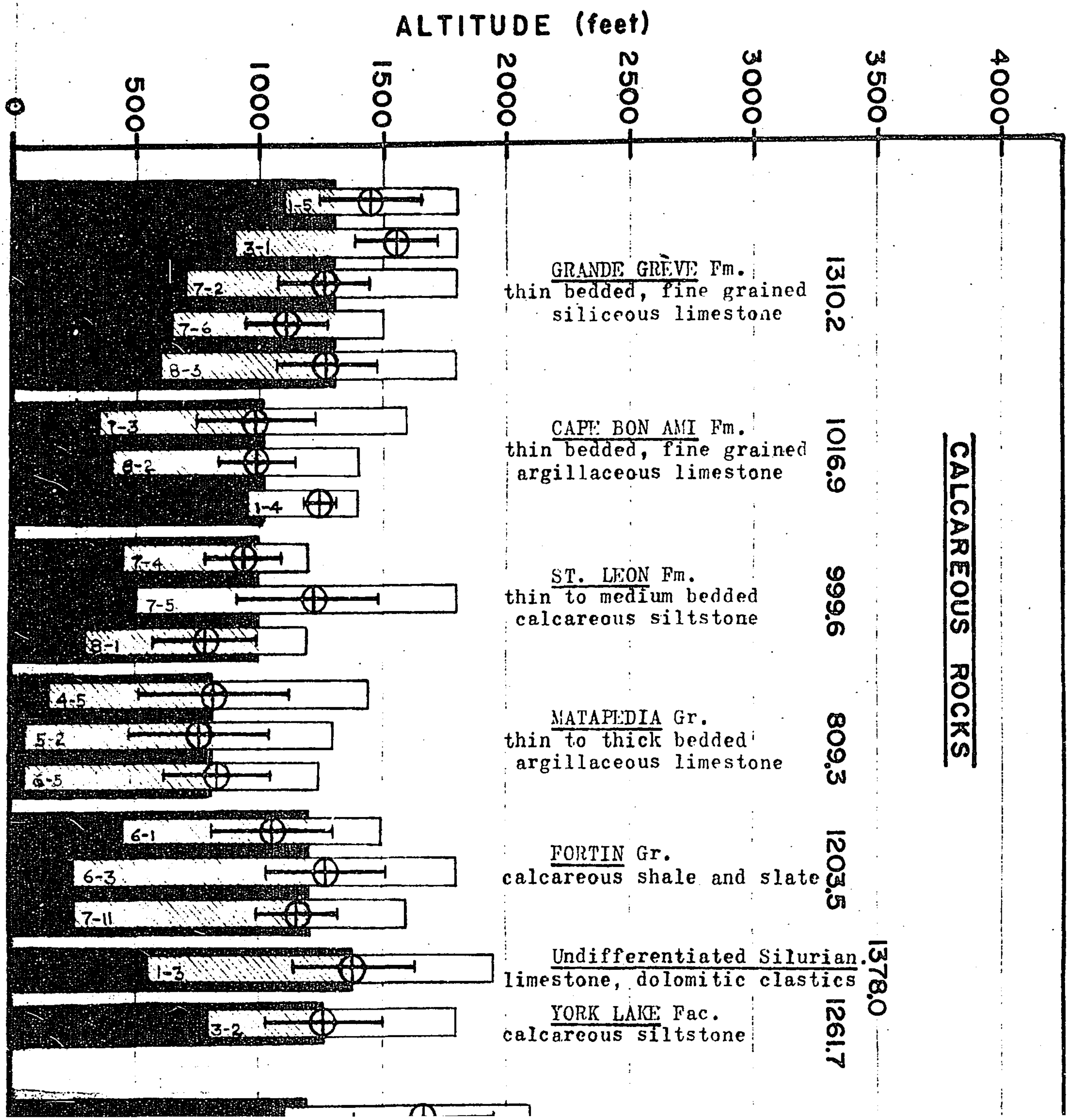
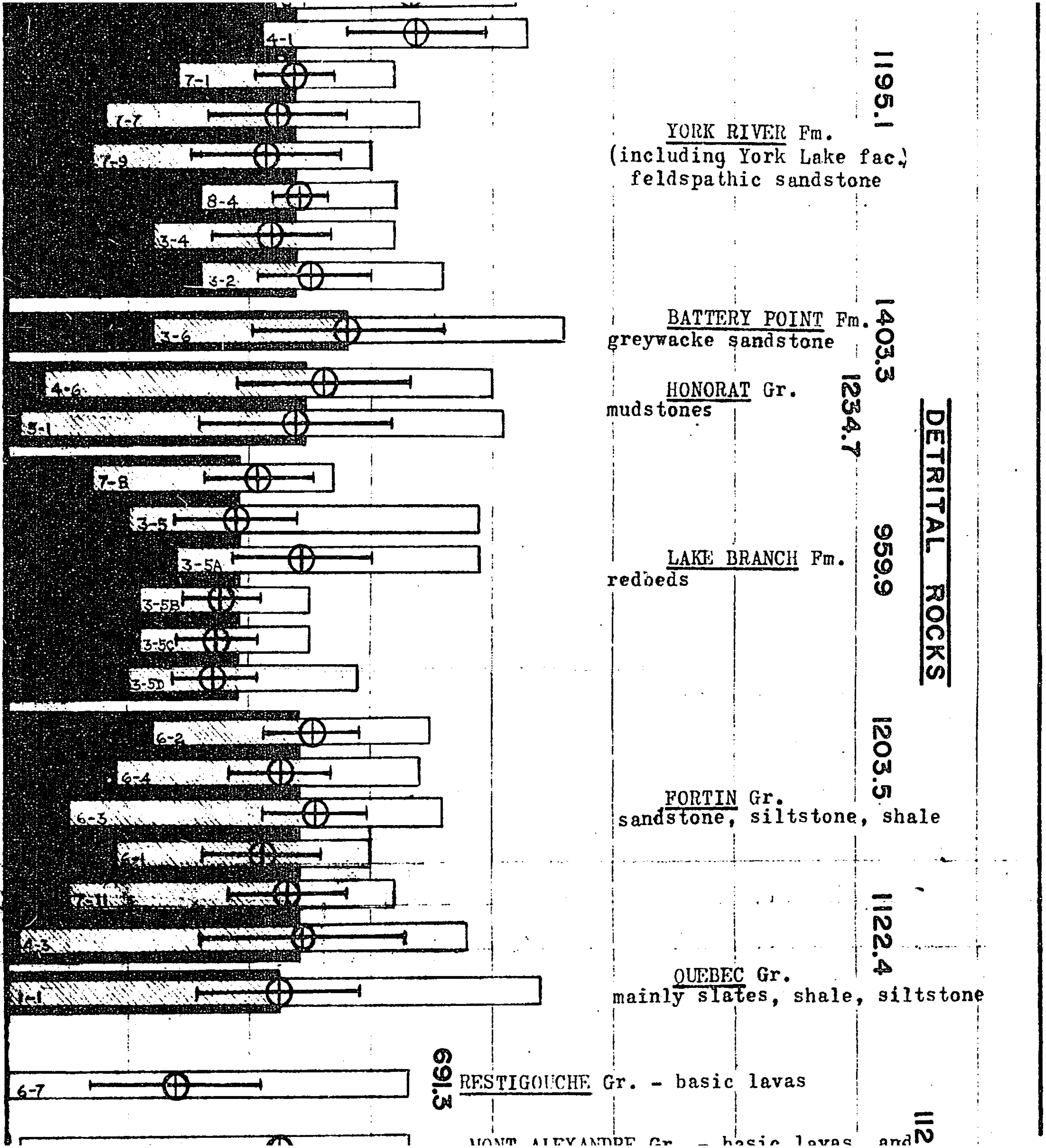
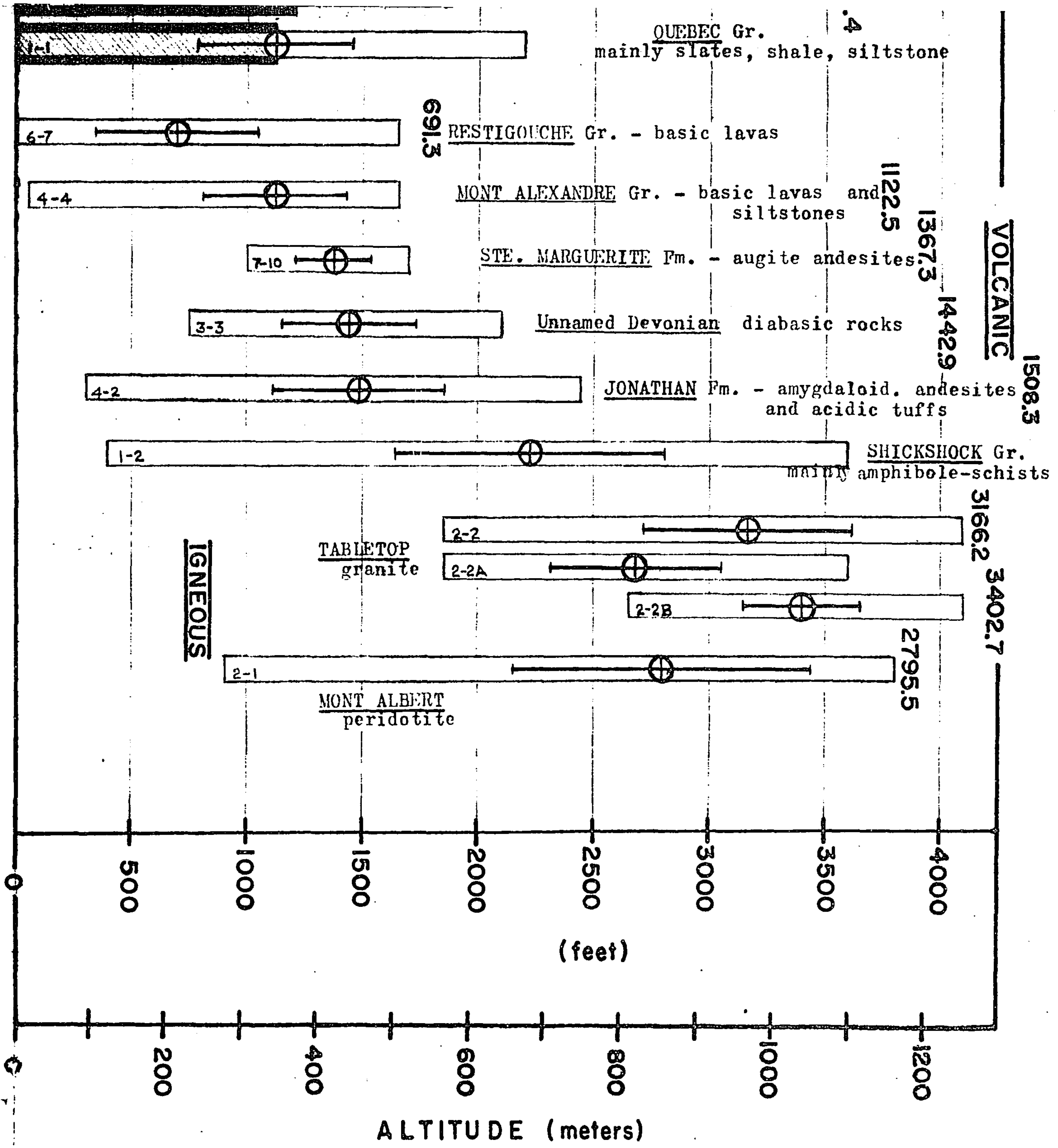


Figure 14.- Plot of Arithmetic Mean Altitude, Standard Deviation, and Range, for units arranged according to similar lithology.


ALTITUDE (feet)
0
500
1000
1500
2000
2500
3000
3500
4000
CALCAREOUS ROCKS
1-5
3-1
7-2
7-6
8-3
GRANDE GRÈVE Fm.
thin bedded, fine grained
siliceous limestone
1310.2
7-3
8-2
1-4
CAPE BON AMI Fm.
thin bedded, fine grained
argillaceous limestone
1016.9
7-4
7-5
8-1
ST. LEON Fm.
thin to medium bedded
calcareous siltstone
999.6
4-5
5-2
6-5
MATAPEDIA Gr.
thin to thick bedded
argillaceous limestone
809.3
6-1
6-3
7-11
FORTIN Gr.
calcareous shale and slate
1203.5
1-3
Undifferentiated Silurian.
limestone, dolomitic clastics
1378.0
3-2
YORK LAKE Fac.
calcareous siltstone
1261.7


4-1
7-1
7-7
7-9
8-4
3-4
3-2
1195.1
YORK RIVER Fm.
(including York Lake fac.)
feldspathic sandstone
3-6
1403.3
BATTERY POINT Fm.
greywacke sandstone
4-6
3-1
1234.7
HONORAT Gr.
mudstones
7-8
3-5
3-5A
3-5B
3-5C
3-5D
959.9
LAKE BRANCH Fm.
redbeds
6-2
6-4
6-3
6-1
7-11
4-3
1203.5
FORTIN Gr.
sandstone, siltstone, shale
1-1
1122.4
QUEBEC Gr.
mainly slates, shale, siltstone
6-7
691.3
RESTIGOUCHE Gr. - basic lavas
MONT ALEXANDRE Gr. - basic lavas and
112
DETRITAL ROCKS



1-1
QUEBEC Gr.
mainly slates, shale, siltstone
.4
6-7
691.3
RESTIGOUCHE Gr. - basic lavas
4-4
MONT ALEXANDRE Gr. - basic lavas and siltstones
1122.5
7-10
STE. MARGUERITE Fm. - augite andesites
1367.3
3-3
Unnamed Devonian diabasic rocks
1442.9
VOLCANIC
4-2
JONATHAN Fm. - amygdaloid. andesites and acidic tuffs
1508.3
1-2
SHICKSHOCK Gr.
mainly amphibole-schists
2-2
3166.2
TABLETOP granite
2-2A
IGNEOUS
2-2B
3402.7
2-1
2795.5
MONT ALBERT peridotite
0
500
1000
1500
2000
2500
3000
3500
4000
(feet)
0
200
400
600
800
1000
1200
ALTITUDE (meters)

each rock type, to an equivalent position at base level (by projecting parallel to the trend of the system). A cursory scale of relative erodibility will be shown, i.e., any vertical plane will show the relative erodibility, by the intersections of the (dashed) projection lines in the plane.

The relative erodibility of rocks found in the thesis area is shown by figure 15, and is tabulated below. Four arbitrary divisions were assigned, for convenience of discussion. Within each, rocks are listed in order of decreasing resistance to erosion:

a)- Resistant rocks: basic volcanics; Honorat Group mudstones and sandstones; Battery Point greywacke sandstone; Silurian dolomitic clastics, dolomite and limestone (undifferentiated);

b)- Moderately resistant rocks: Fortin Group sandstones, siltstones, and slate; Quebec Group shale, slate, with resistant quartzite bands; the Grande Grève siliceous limestone; and York River feldspathic sandstone;

c)- Weak rocks: Cape Bon Ami Formation, and Matapedia Group argillaceous limestones, and the St. Leon Formation calcareous siltstones;

d)- Very weak rocks: the Restigouche Group mudstones and basic volcanic rocks; and the poorly consolidated Lake Branch Formation redbeds (shale with siltstone). (The Restigouche Group lithology suggests a greater resistance; possibly the nearness to the sea or the faulting across the unit may unduly effect the value of relative erodibility.)

The relative erodibility scale shows volcanic rocks less easily erodible than sedimentary. Also, sandstones as a group are more resistant than limestones which are stronger than shales. This follows permeability (Leopold, Wolman and Miller, 1964, p.101), considered a major factor in denudation. Note that figure 14 shows Battery Point rocks highest of sandstones; but with regional slope removed, the Honorat Group appear to be more resistant.

Similarly, figure 14 shows the Matapedia Group argillaceous limestones with the lowest mean altitude of the limestone group. However, when the effects of regional slope are removed, as shown by figure 15, the rock type has a relative resistance to erosion roughly equal to that of the Cape Bon Ami and St. Leon formations.

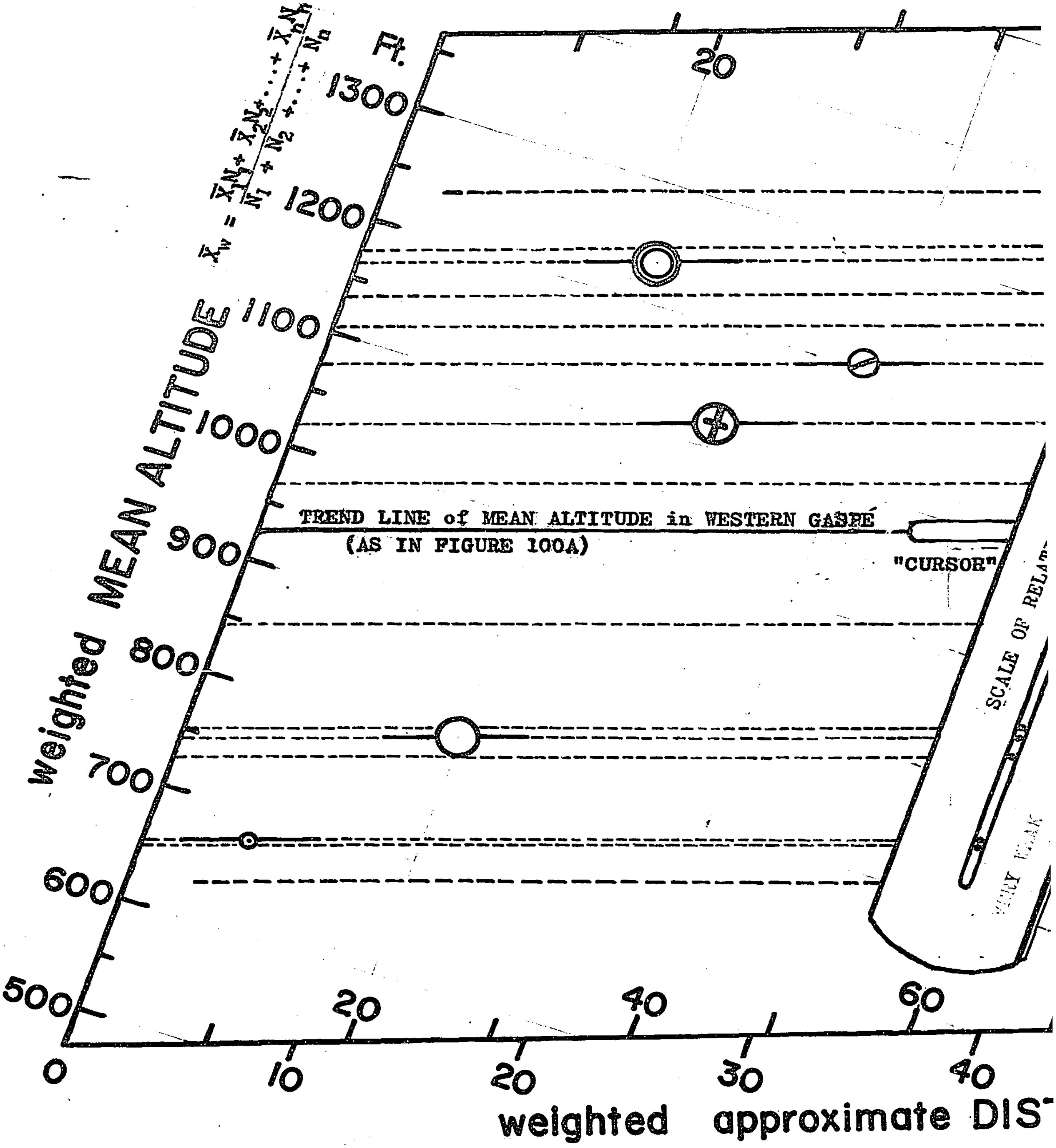
Differential erosion can be obtained in terms of altitude difference by comparing the values of altitude for the units projected to base level.

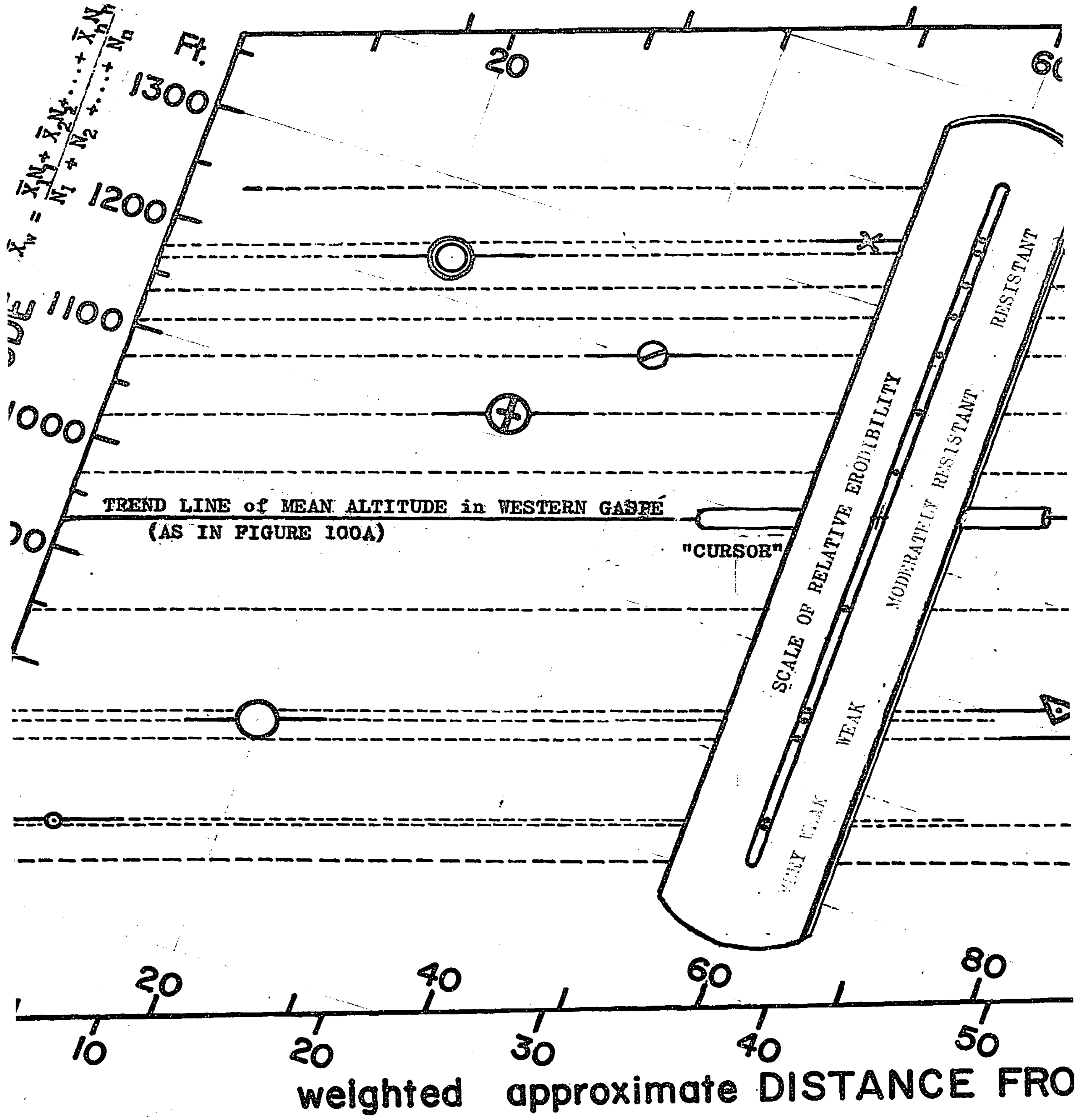
In some parts of western Gaspé there arise questions as to whether faulting or differential erosion has caused a particular landform. For example, in the Big Berry Mountains map-area many consider faulting as the cause of the Big Berry Mountains escarpment, found between the Lake Branch and Battery Point formations. Carbonneau (1953, p. 75-76) advocates differential erosion:

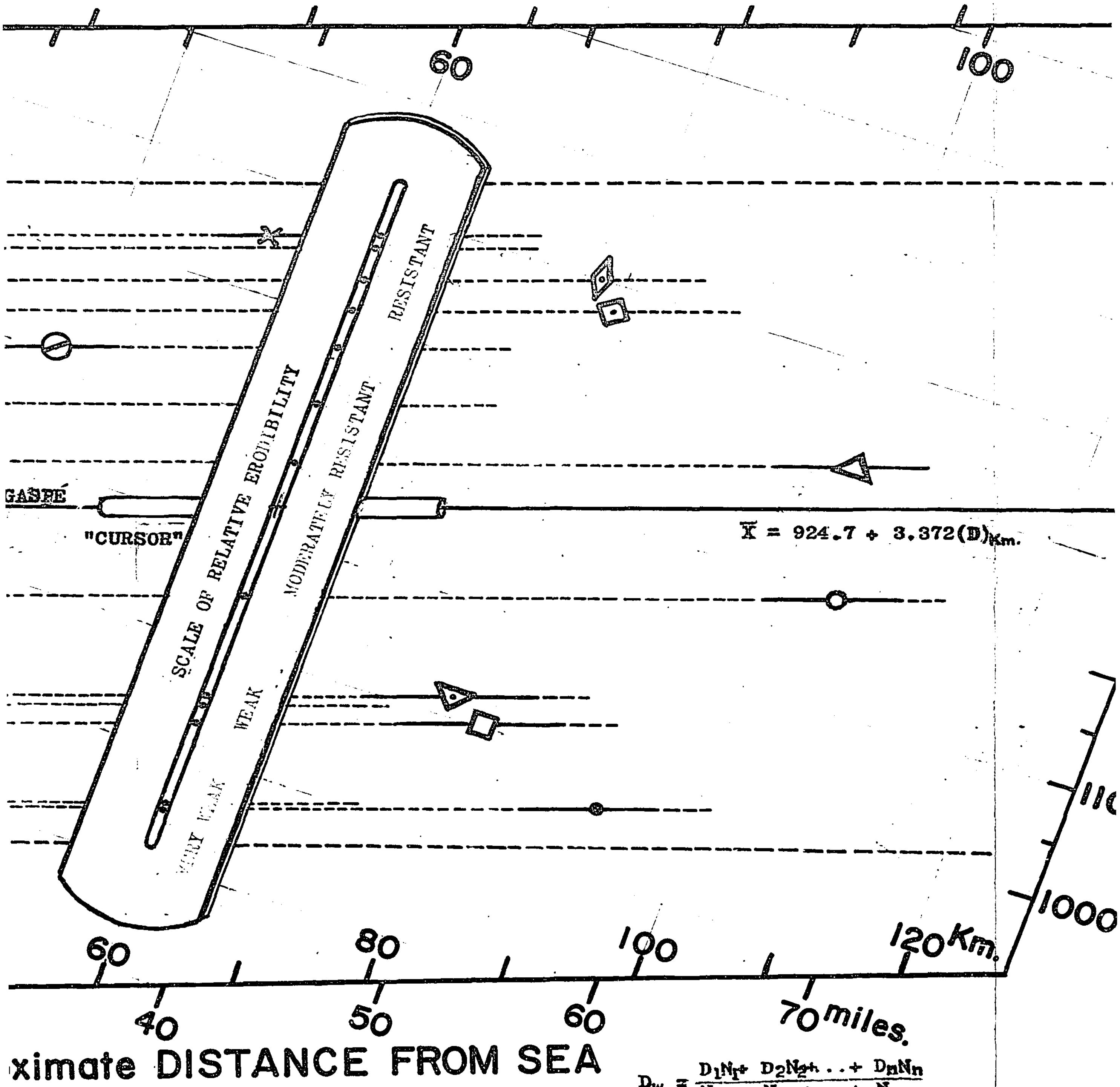
> "The idea of faulting along the Berry Mountain escarpment is attractive on account of the topographic break at this front. Irregularities in strikes and dips of the Battery Point beds in the vicinity of Mount Noble also suggest faulting.
>
> There is no faulting however in the Inlet River section, and the escarpment does not follow the trend of the rock formations west of Loon Lake. The escarpment is most likely due to the friability and poor state of consolidation of the Lake Branch formation compared with the resistant Battery Point sandstones."

Figure 15 shows that for the two formations involved, the value of differential erosion is close to the maximum found in the Gaspé. Thus, the view quoted above might well be the correct one.

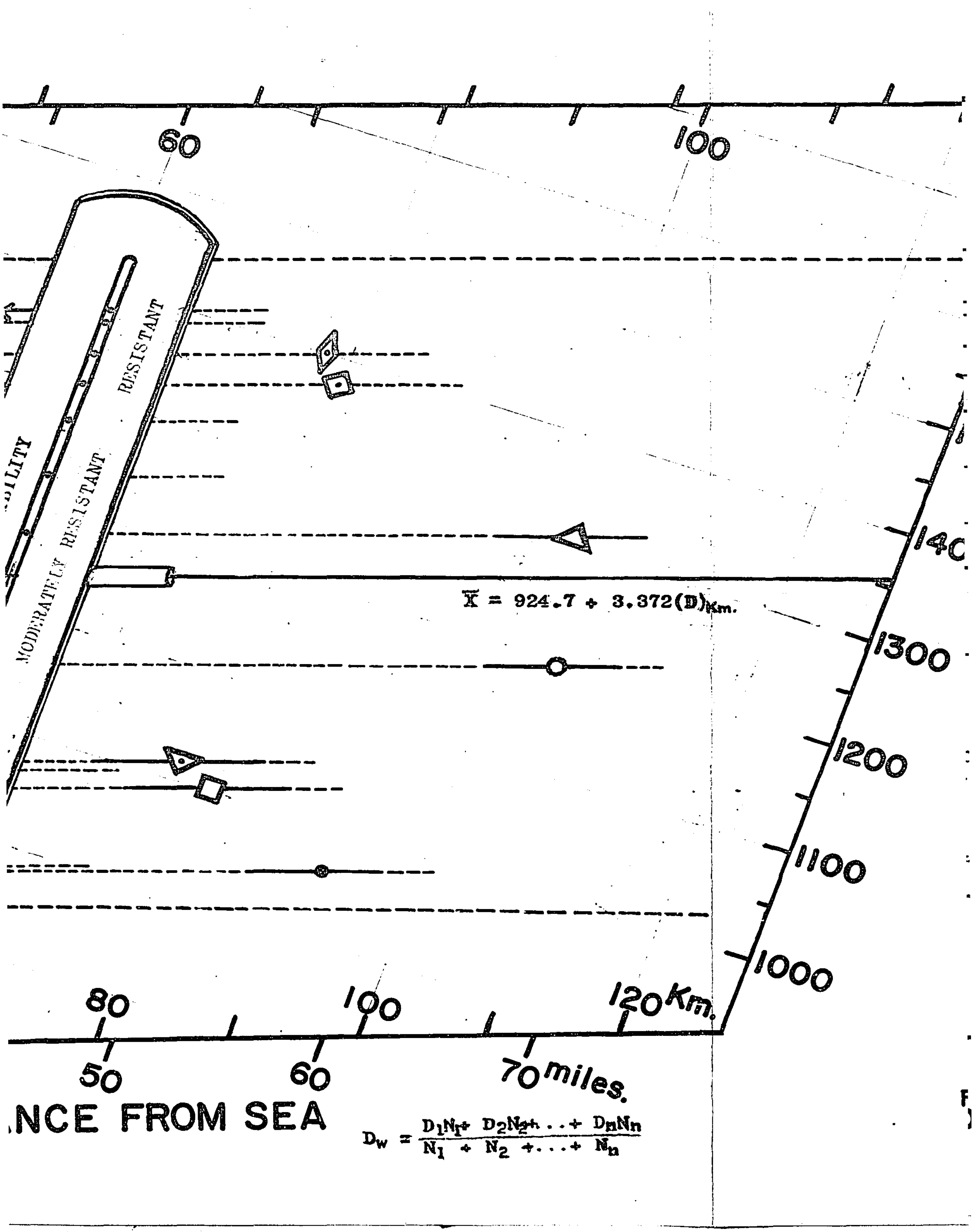
In summary, the figures 14 and 15 can be compared with table 3, p. 81, to show that there is a very definite correlation between the arithmetic mean altitude of populations supported by various types of bedrock, and the lithology of the rock units. The relative erodibility of units can be obtained if the means are considered within the framework of the overall topographic system.

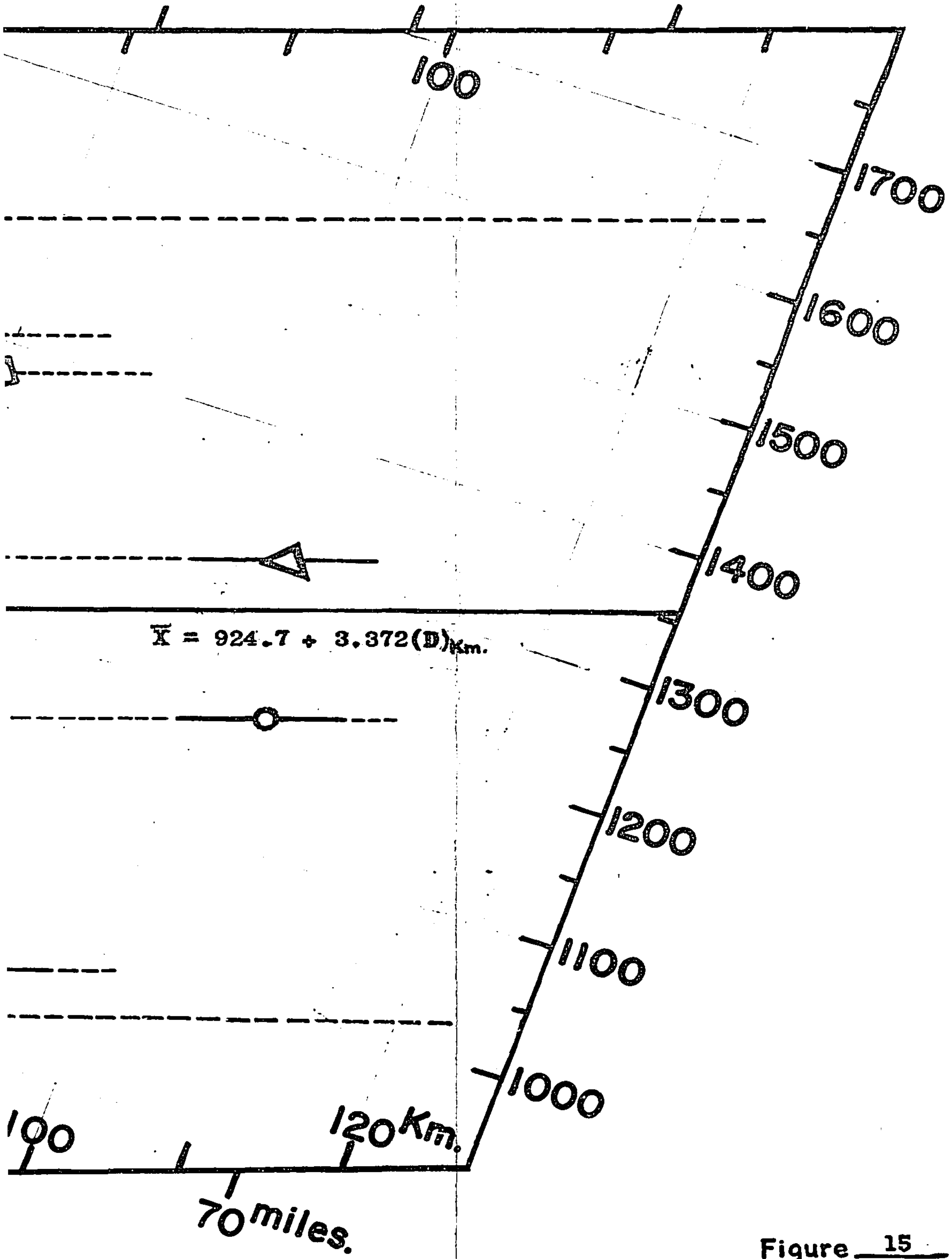
$\bar{X}_w = \frac{\bar{X}_1N_1 + \bar{X}_2N_2 + \dots + \bar{X}_nN_n}{N_1 + N_2 + \dots + N_n}$
Ft.
1300
1200
1100
1000
900
800
700
600
500
weighted MEAN ALTITUDE
20
TREND LINE of MEAN ALTITUDE in WESTERN GASPÉ
(AS IN FIGURE 100A)
"CURSOR"
SCALE OF RELA
VERY WEAK
20
40
60
0
10
20
30
40
weighted approximate DIS


$\bar{X}_w = \frac{\bar{X}_1N_1 + \bar{X}_2N_2 + \ldots + \bar{X}_nN_n}{N_1 + N_2 + \ldots + N_n}$
Ft.
1300
1200
1100
1000
00
DE
20
60
TREND LINE of MEAN ALTITUDE in WESTERN GASPÉ
(AS IN FIGURE 100A)
"CURSOR"
SCALE OF RELATIVE ERODIBILITY
RESISTANT
MODERATELY RESISTANT
WEAK
VERY WEAK
20
40
60
80
10
20
30
40
50
weighted approximate DISTANCE FRO



$$D_w = \frac{D_1N_1 + D_2N_2 + \ldots + D_nN_n}{N_1 + N_2 + \ldots + N_n}$$


60
100
RESISTANT
MODERATELY RESISTANT
BILITY
X̄ = 924.7 + 3.372(D)Km.
140
1300
1200
1100
1000
80
100
120Km.
50
60
70miles.
NCE FROM SEA
Dw = D1N1+ D2N2+ . . + DnNn / N1 + N2 +. . .+ Nn



LEGEND

NORTHERN BEL

Quebec Gr

CENTRAL BELT

Battery Point F

York River Fm
incl. York Lak

Lake Branch Fm

Fortin Gr

Grande Grève Fm

Cape Bon Ami Fm

St Leon Fm

Undiff. Siluria

Volcanics
(units 3-3,4-2,

SOUTHERN BEL

Restigouche Gr

Matapedia Gr

Honorat Gr

Figure 15 Relative erodibility di
For western Gaspé.

$$D_W = \frac{D_1N_1 + D_2N_2 + \ldots + D_nN_n}{N_1 + N_2 + \ldots + N_n}$$

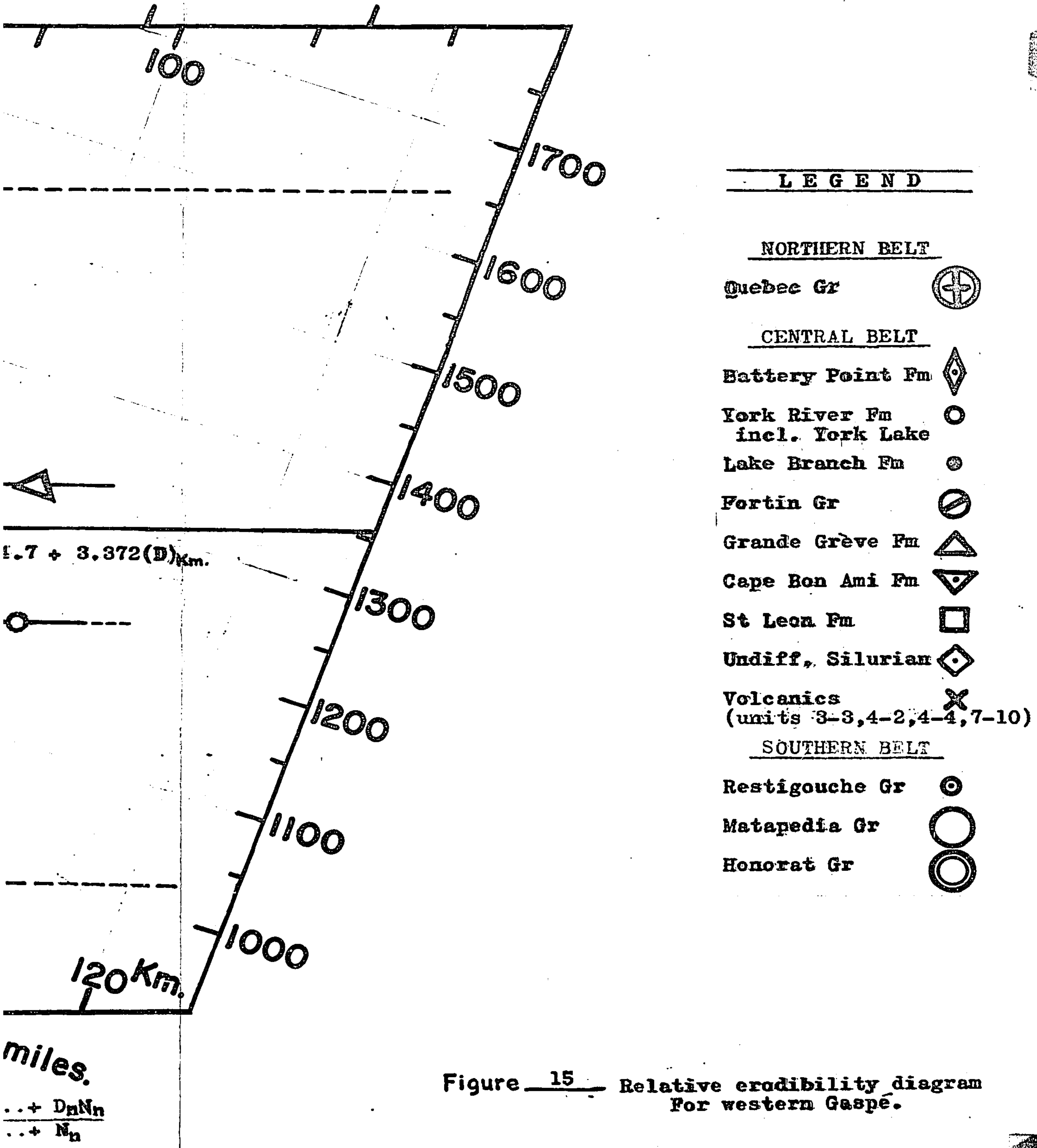
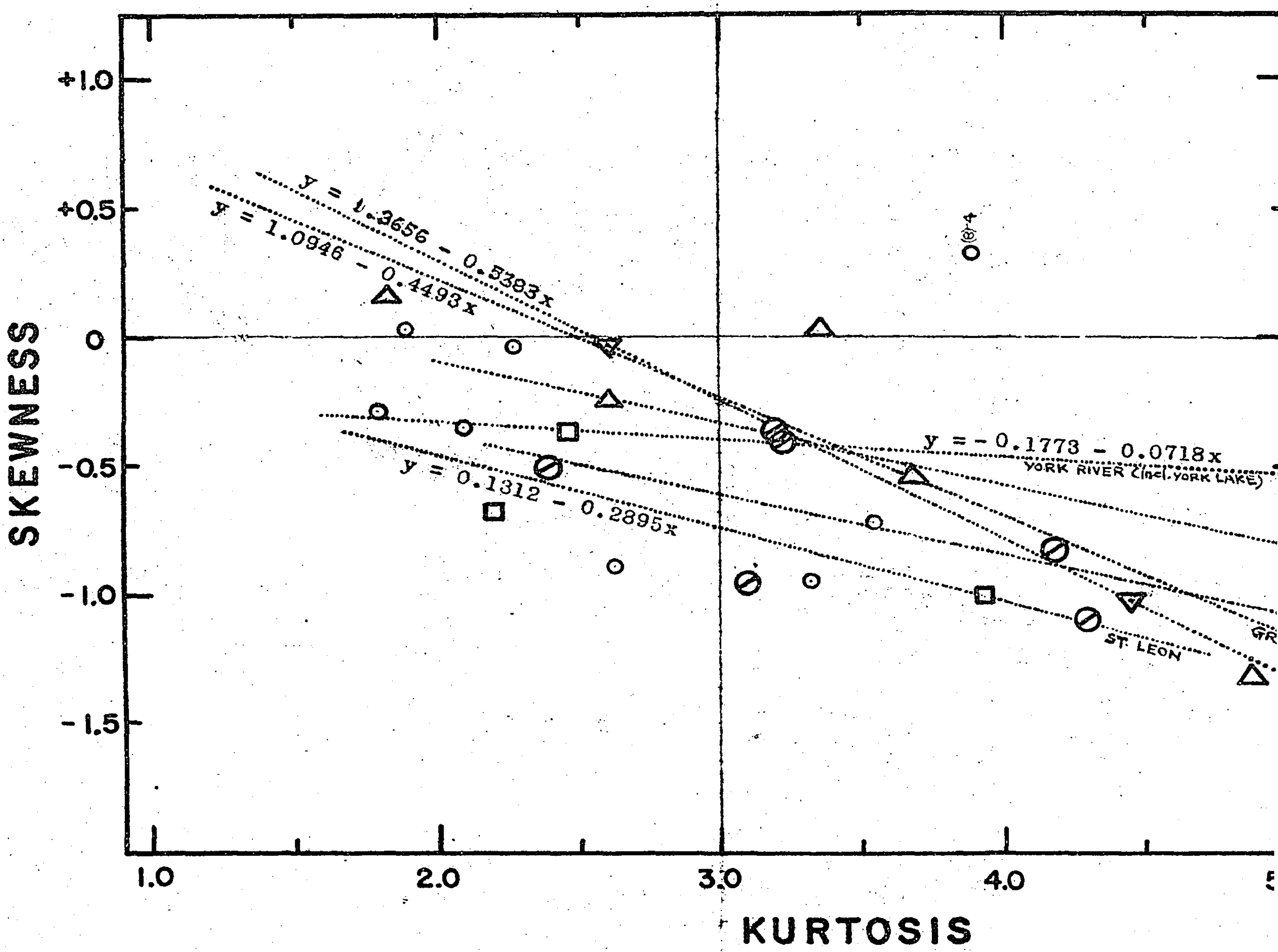
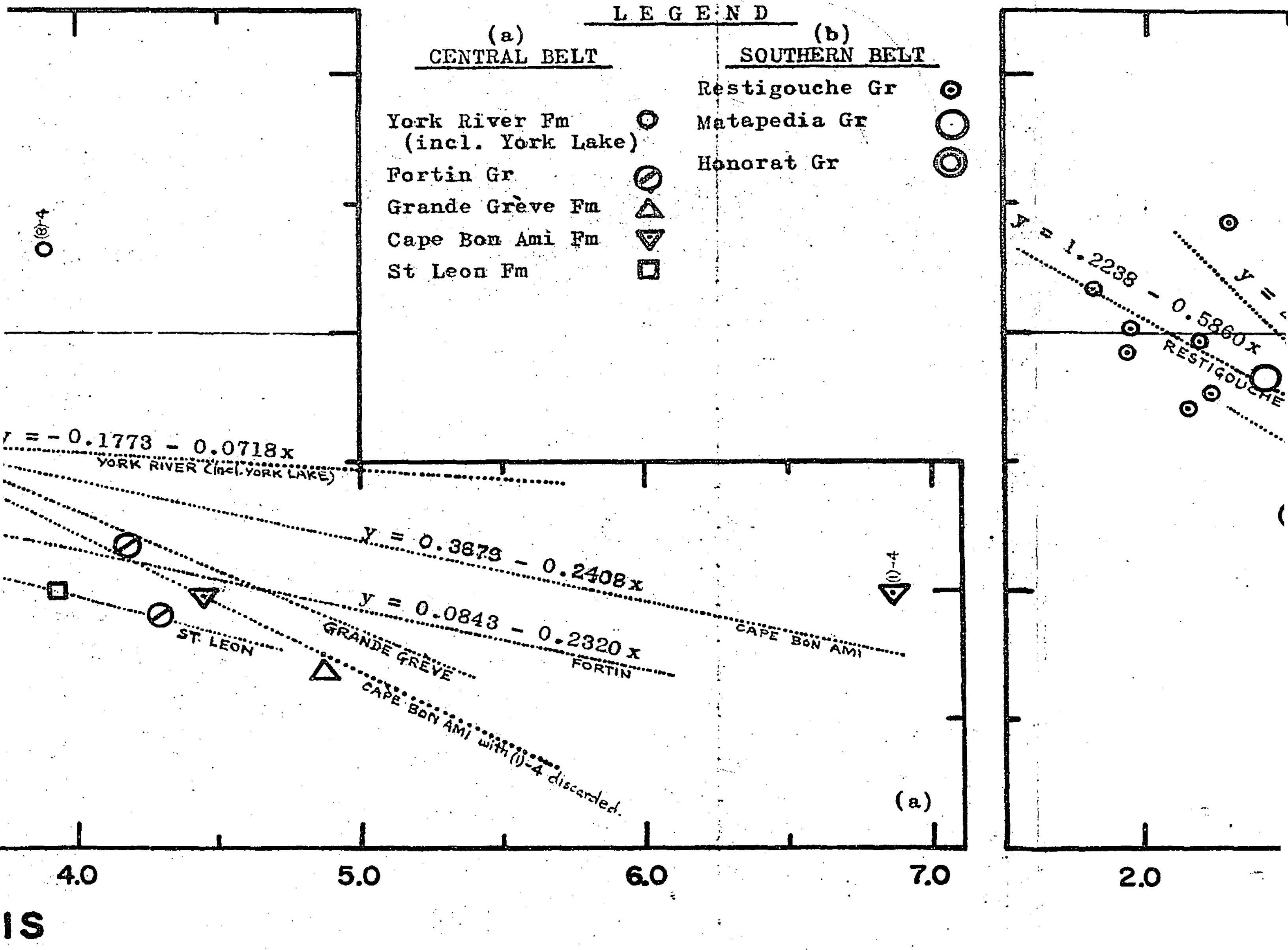


Figure 15 Relative erodibility diagram For western Gaspé.

4.2 Trends among the frequency distribution parameters.

In order to summarily show that there is a definite relationship between the various frequency distribution of altitude curve parameters, figures 16, 17, and 18 are included on p. 90, 91, and 92 respectively. These show scatter plots between skewness, kurtosis, and standard deviation, to which first order linear trend lines have been fitted, for each rock type, according to the least squares method. For the skewness-vs-kurtosis and kurtosis-vs-standard deviation plots, the trends for individual rock types all have about the same general orientation, indicating that while there is a variability according to lithology, the units are from the same general system which could be defined by characteristic values of these parameters. These plots might be useful in defining "suites of topography" . The western Gaspé suite might be described by an average skewness value of -0.5; an average kurtosis value of 3.0; and a standard deviation of about 200 ft. These are the same values which are found to define the system from the plot of figure 100, on which they are more clearly evident. The scatter diagram of skewness-vs-standard deviation avails a jumble of trends, but it is observed that detrital rocks have an orientation different from the calcareous rocks. Whether this is meaningful or not will not be considered at this time. The fitting of trend lines to the unit properties is to some extent misleading, for it must be assumed that each plotted point is of the same value as the rest. This is not entirely so, for the areas from which the samples were drawn varied in size. However, they are worth including in order to show that the variation of the parameters amongst themselves is probably linear. The best example of linear trend lines is the plotting for the Grande Grève formation.


SKEWNESS
+1.0
+0.5
0
-0.5
-1.0
-1.5
1.0
2.0
3.0
4.0
5
KURTOSIS
y = 1.3656 - 0.5383x
y = 1.0946 - 0.4493x
(8)-4
y = - 0.1773 - 0.0718x
YORK RIVER (incl. YORK LAKE)
y = 0.1312 - 0.2895x
ST. LEON
GR



L E G E N D
(a)
CENTRAL BELT
York River Fm (incl. York Lake) ○
Fortin Gr ⊘
Grande Grève Fm △
Cape Bon Ami Fm ▽
St Leon Fm □
(b)
SOUTHERN BELT
Restigouche Gr ⊙
Matapedia Gr ○
Honorat Gr ◎
(8)-4
y = - 0.1773 - 0.0718x
YORK RIVER (incl. YORK LAKE)
y = 0.3873 - 0.2408x
CAPE BON AMI
y = 0.0843 - 0.2320 x
FORTIN
ST. LEON
GRANDE GREVE
CAPE BON AMI with (i)-4 discarded.
(i)-4
(a)
4.0
5.0
6.0
7.0
IS
y = 1.2238 - 0.5860x
RESTIGOUCHE
y =
2.0

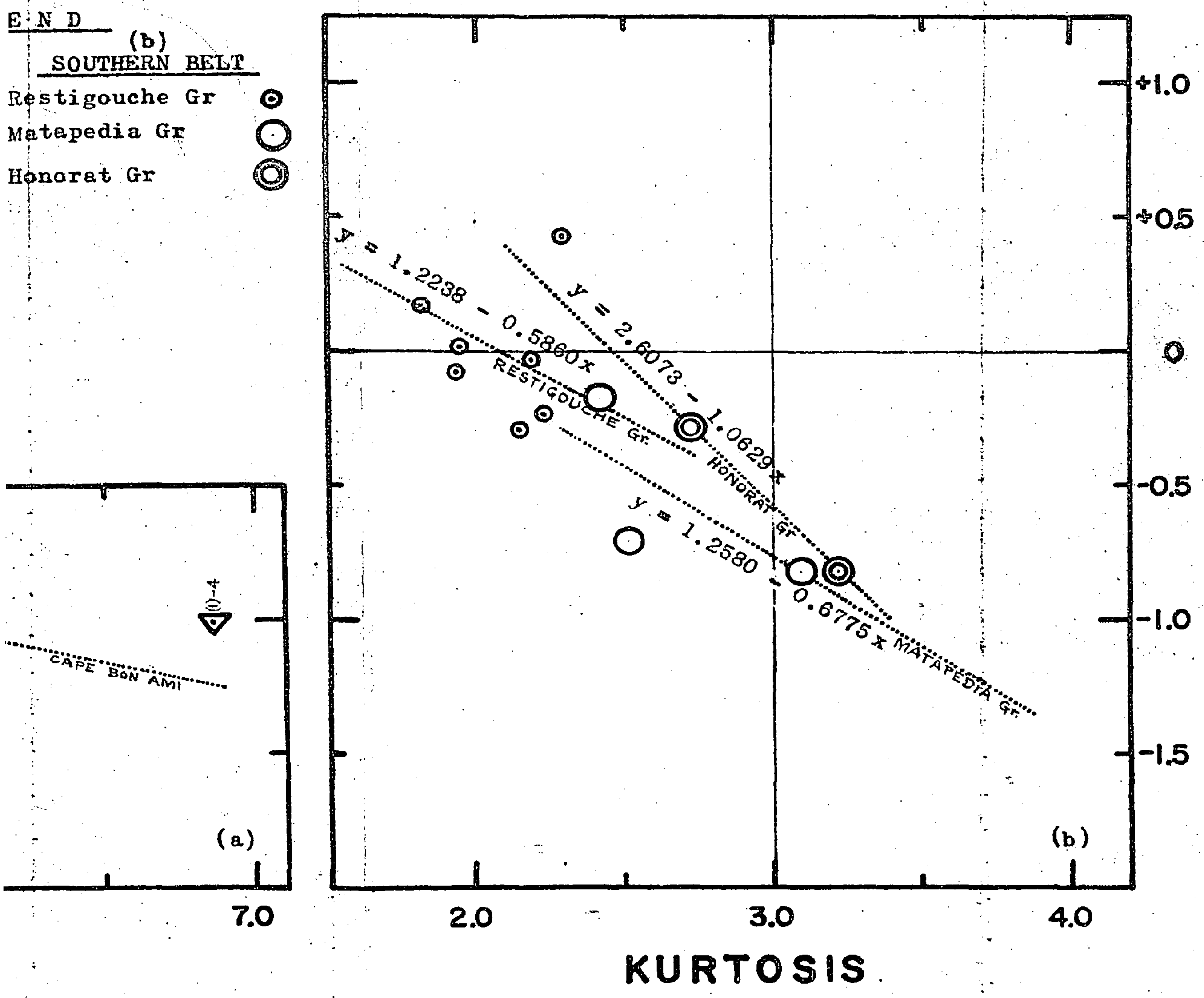
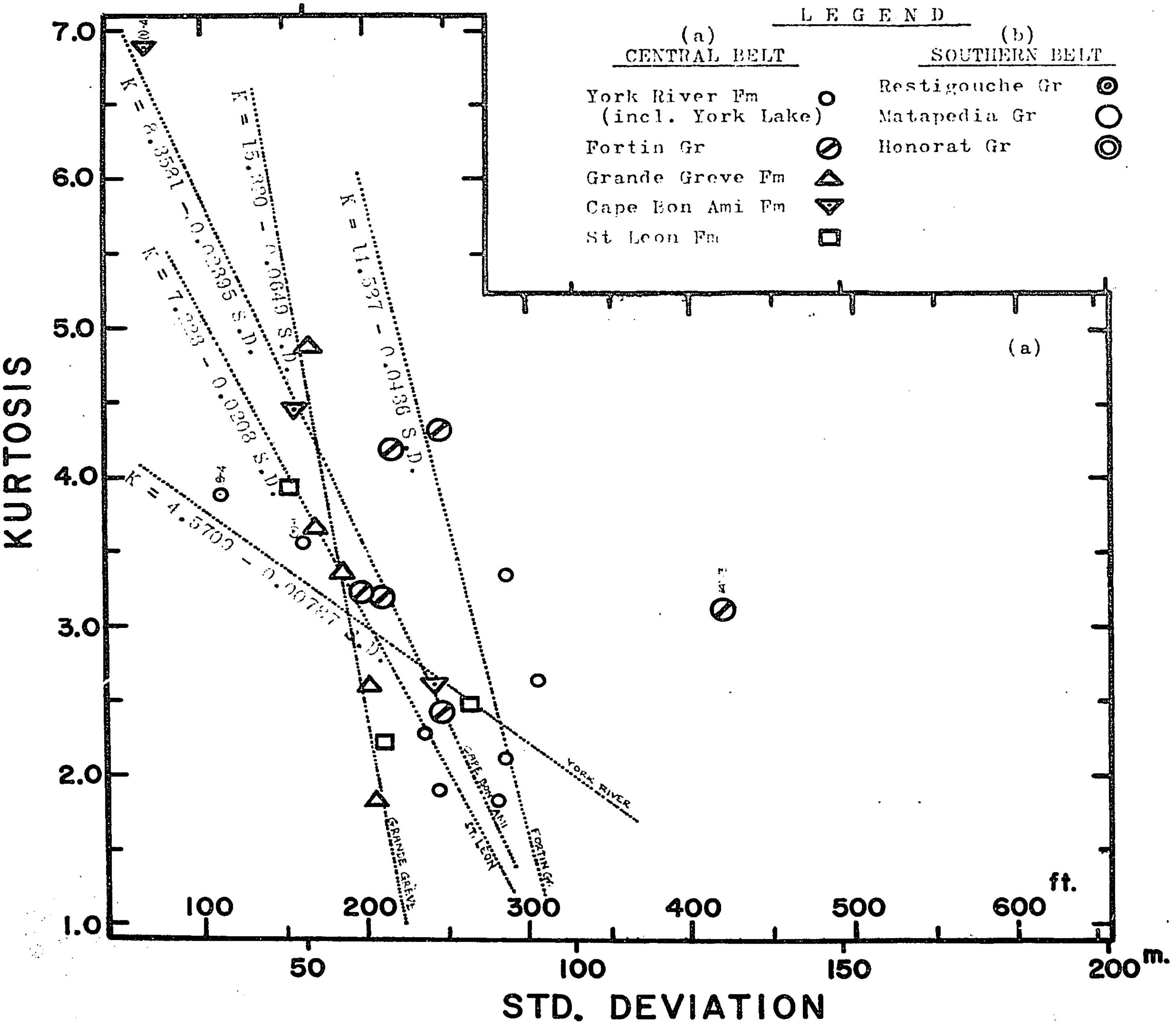


Figure 16 .— Scatter diagram: Skewness vs Kurtosis.

LEGEND
(a)
CENTRAL BELT
York River Fm ○
(incl. York Lake)
Fortin Gr ⊘
Grande Greve Fm △
Cape Bon Ami Fm ▽
St Leon Fm □
(b)
SOUTHERN BELT
Restigouche Gr ◉
Matapedia Gr ○
Honorat Gr ◎
(a)
K = 8.3521 – 0.02395 S.D.
K = 15.320 – 0.0649 S.D.
K = 11.537 – 0.0436 S.D.
K = 7.[illegible]3 – 0.0208 S.D.
K = 4.5709 – 0.00787 S.D.
10-4
9-4
GRANDE GREVE
ST. LEON
CAPE BON AMI
FORTIN GR.
YORK RIVER
KURTOSIS
7.0
6.0
5.0
4.0
3.0
2.0
1.0
100
200
300
400
500
600
ft.
50
100
150
200
m.
STD. DEVIATION

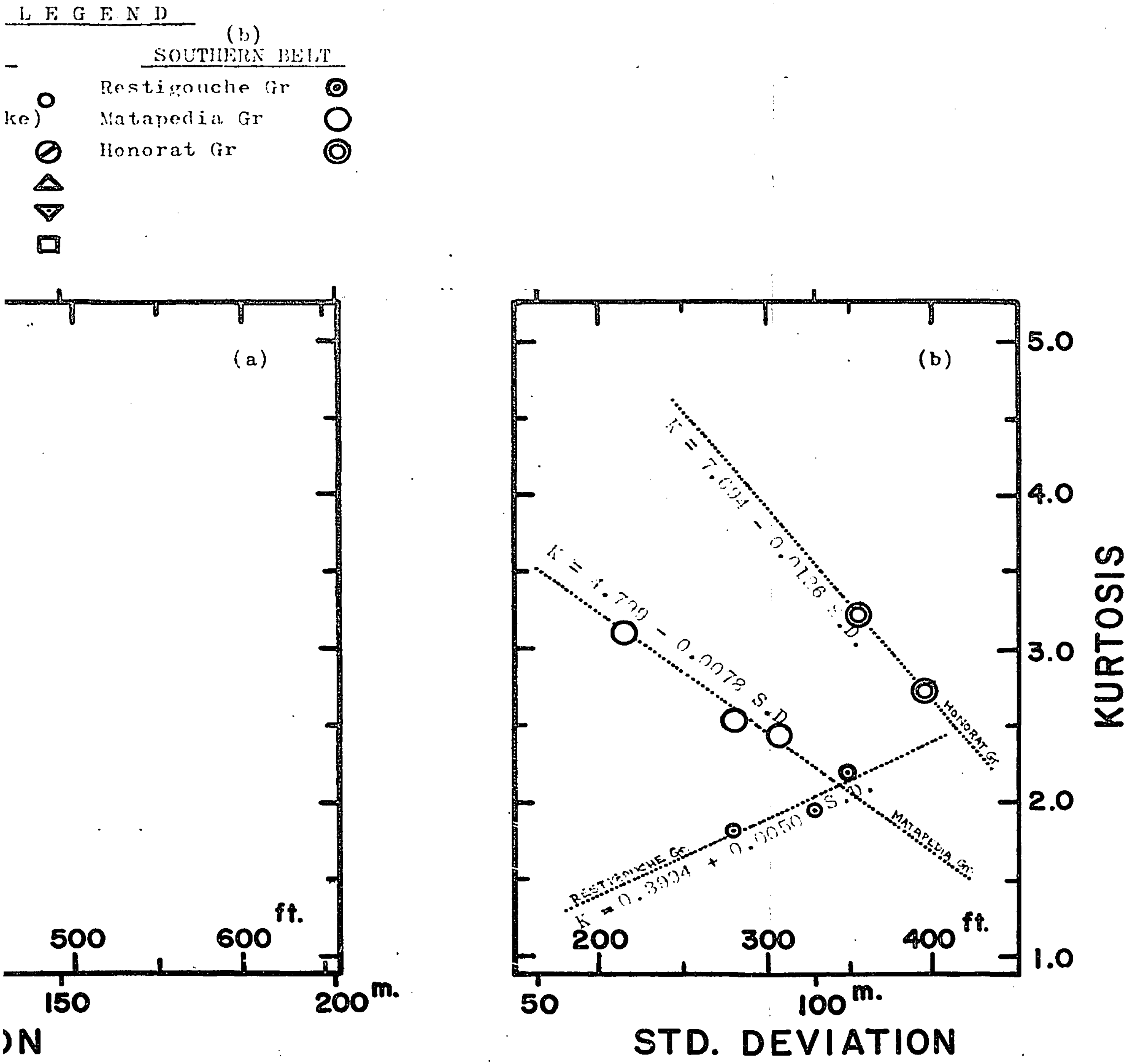
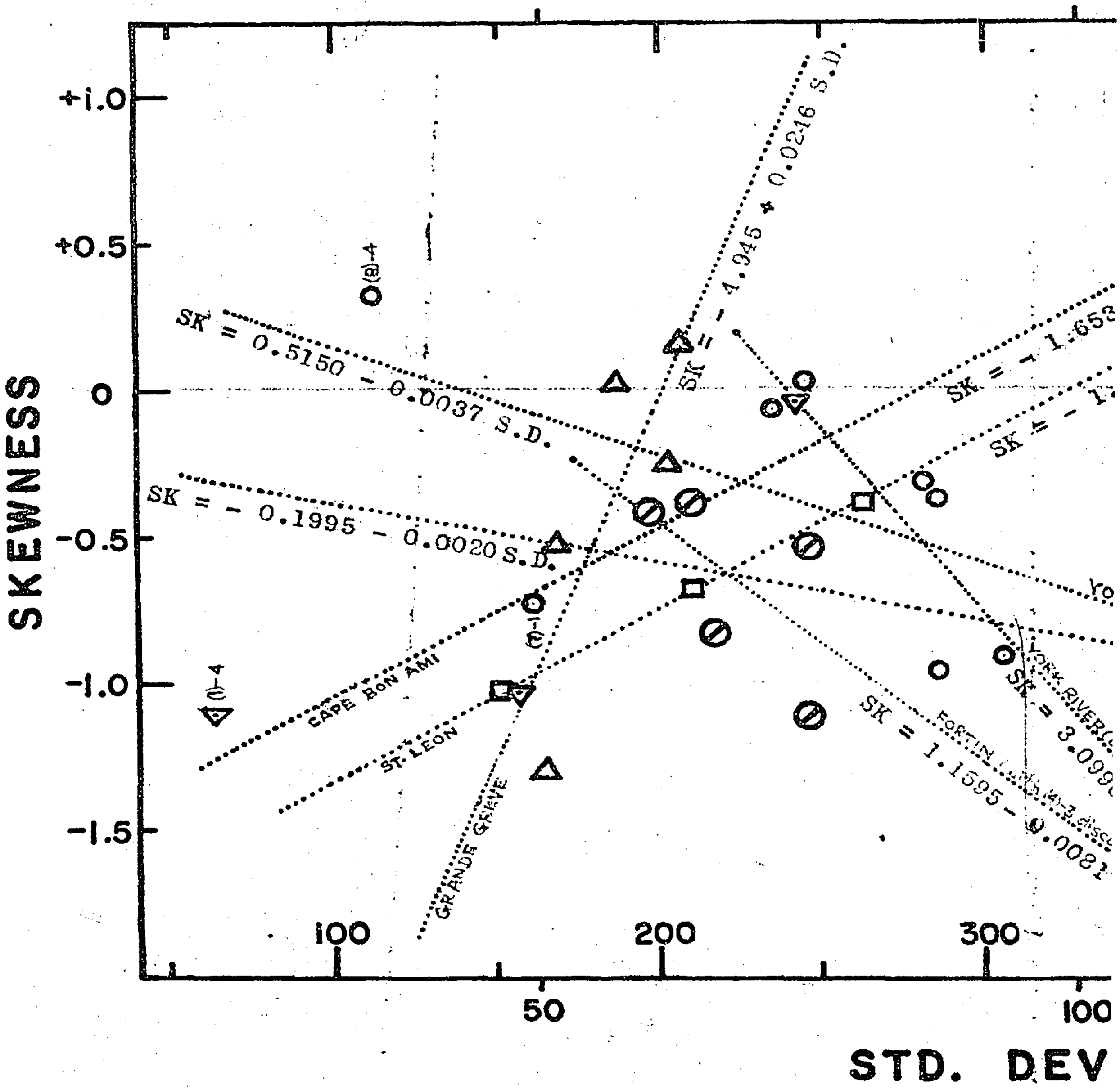
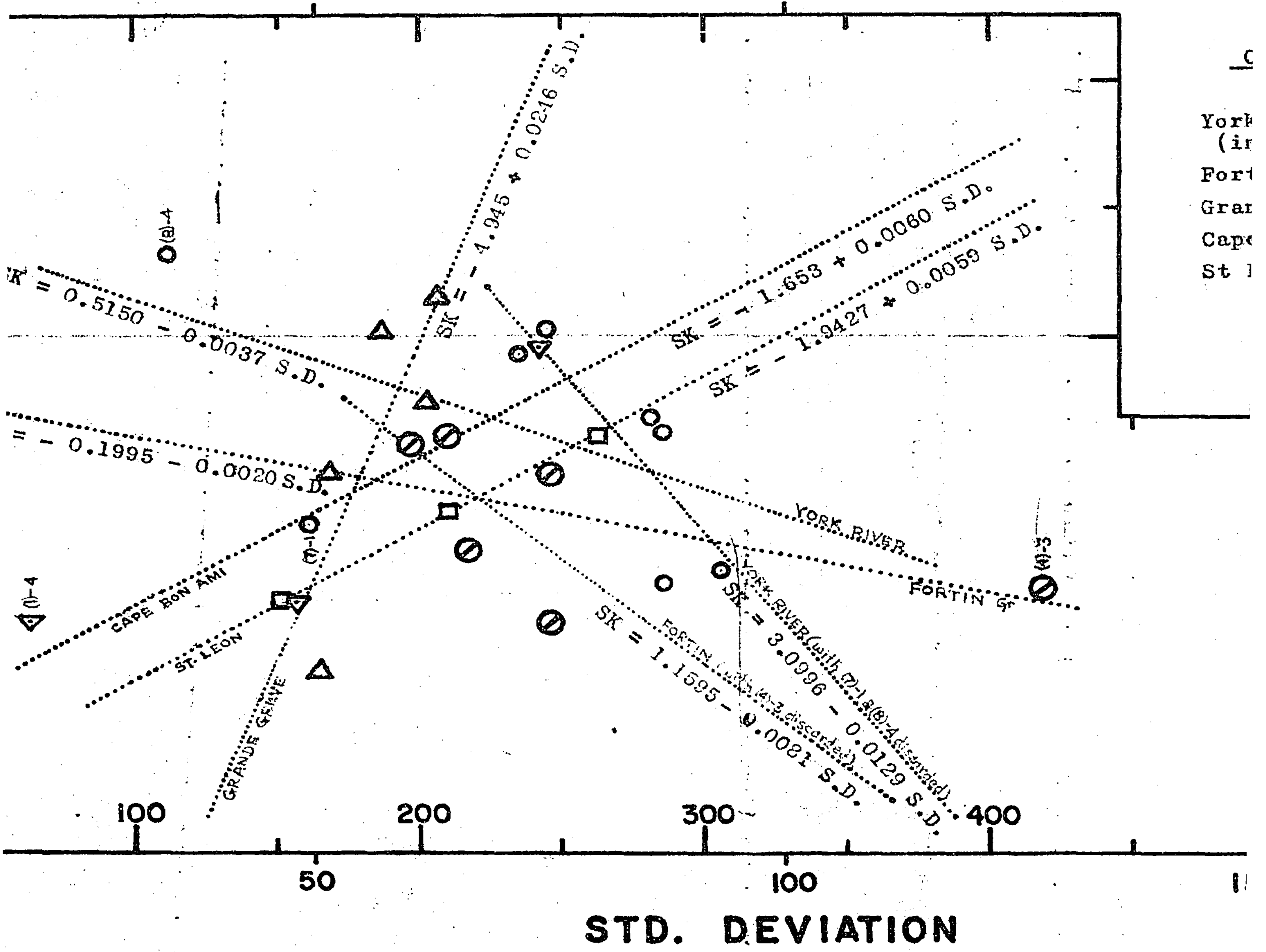
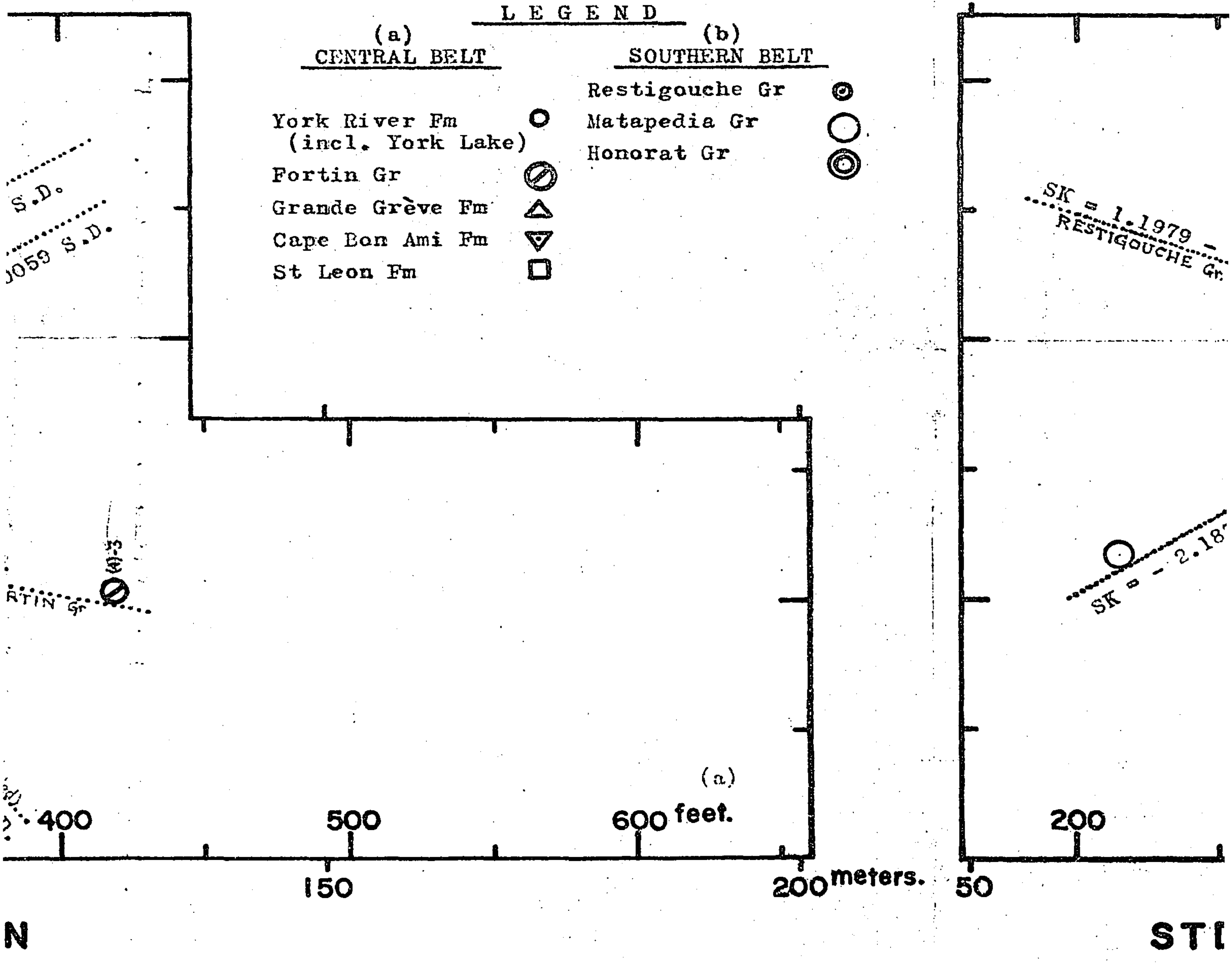


Figure 17 .- Scatter diagram: Kurtosis vs Standard Deviation.


SKEWNESS
+1.0
+0.5
0
-0.5
-1.0
-1.5
(B)-4
(I)-1
(I)-4
SK = 0.5150 - 0.0037 S.D.
SK = - 0.1995 - 0.0020 S.D.
SK = - 4.945 + 0.0216 S.D.
SK = - 1.653
SK = - 1
SK = 3.099
SK = 1.1595 - 0.0081
YO
YORK RIVER(
FORTIN
CAPE BON AMI
ST. LEON
GRANDE GREVE
100
200
300
50
100
STD. DEV



K = 0.5150 - 0.0037 S.D.
= - 0.1995 - 0.0020 S.D.
SK = - 4.945 + 0.0216 S.D.
SK = - 1.653 + 0.0060 S.D.
SK = - 1.9427 + 0.0059 S.D.
SK = 3.0996 - 0.0129 S.D.
SK = 1.1595 - 0.0081 S.D.
YORK RIVER
FORTIN St
CAPE BON AMI
ST. LEON
GRANDE GREVE
FORTIN (with (4)-3 discarded)
YORK RIVER (with (7)-1 & (8)-4 discarded)
(8)-4
(7)-1
(1)-4
(4)-3
100
200
300
400
50
100
STD. DEVIATION
York
(ir
Fort
Gran
Cape
St l


LEGEND
(a)
CENTRAL BELT
York River Fm ○
(incl. York Lake)
Fortin Gr ⊘
Grande Grève Fm △
Cape Bon Ami Fm ▽
St Leon Fm □
(b)
SOUTHERN BELT
Restigouche Gr ◉
Matapedia Gr ○
Honorat Gr ◎
S.D.
0059 S.D.
RTIN Gr
40-3
SK = 1.1979 -
RESTIGOUCHE Gr
SK = - 2.18
(a)
400
500
600 feet.
150
200 meters.
200
50
N
STI
F

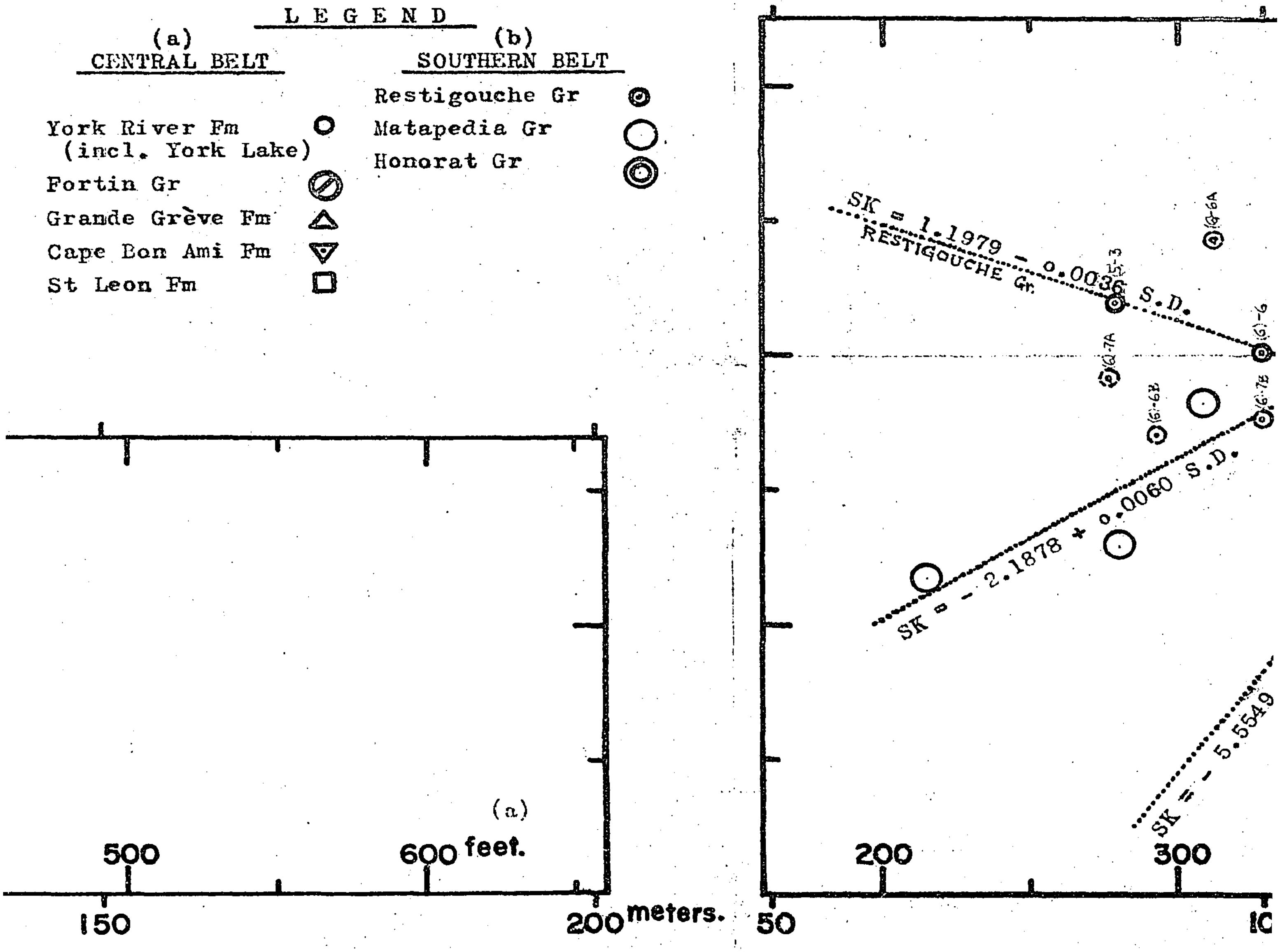


Figure 18. — Sc
Skewness v

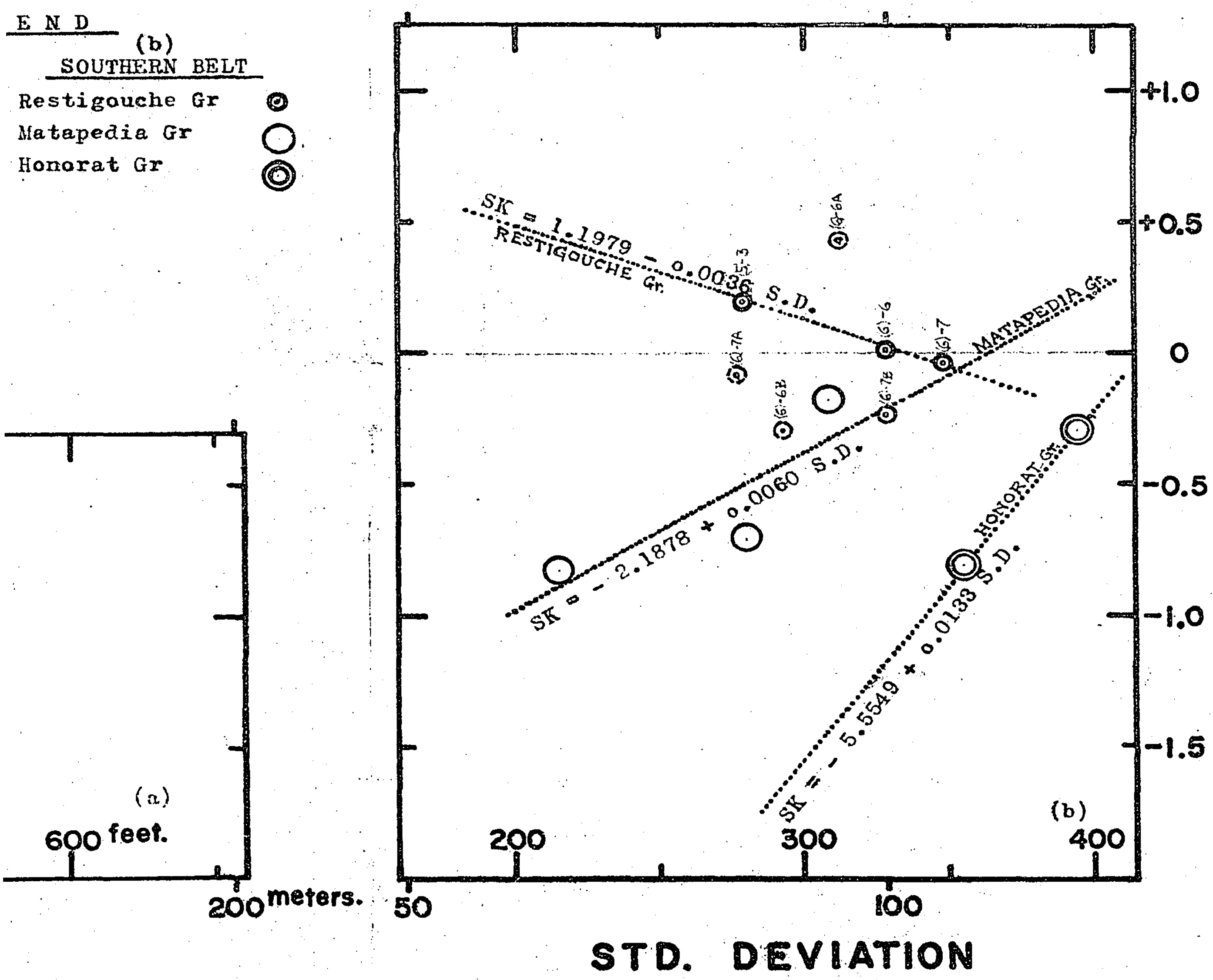


Figure 18. — Scatter diagram: Skewness vs Standard Deviation.

4.3 Conclusions and suggestions for further work.

4.3-(1) Frequency distribution analysis of altitude.

(a)- The frequency distribution analysis of erosional topography considered as populations of altitude supported by lithologic units at the Formation level, appears to be a reasonable method of landscape description.

(b)- The method is quantitative. Rigorous statistical techniques may be applied; or the observed data can be subjected to analytical-descriptive comparisons, (as in this study). The approach is in accordance with the concept of dynamic equilibrium advanced by Hack (1960).

(c)- The method depends upon the availability of both topographic and geologic mapping at an equivalent scale for the area under consideration. The initial time required to obtain the sample data is considerably long but all subsequent steps in the analysis, including the graphing of values, can be performed by electronic computer.

4.3-(2) The topographic system of western Gaspé.

(a)- On the basis of available evidence from this study, and according to the logic of the approach, the concept of dynamic equilibrium of Hack (1960) is thought to apply to western Gaspé. The plot of arithmetic mean altitude, standard deviation, skewness, and kurtosis measures of frequency distributions of altitude based on lithology, against the distance of the rock-topographic units from the sea (base level) shows in each case a well defined trend of linear variability. Individual rock types with more than one sample unit, show trends which in most cases are parallel or subparallel to that for the system. Thus, the topography is considered erosionally graded to base level; and the gross landform elements (rock-topographic units) are mutually adjusted within the system, and are downwasting at rates equal to their individual resistances to erosion (including weathering and mass wasting processes).

(b)- The topographic system of western Gaspé is considered to be defimed by the equations given below, which determime the trends of descriptive parameters of frequency distributions of altitude based on Formation units of uniform bedrock geology, in relation to base level control;

$$\overline{X} = 924.7 \text{ ft.} + 3.372(D) \ldots\ldots\ldots\ldots 1.$$

$$S.D. = 321.6 \text{ ft.} - 1.050(D) \ldots\ldots\ldots\ldots 2.$$

$$SK = -0.5118 + 0.00094(D) \ldots\ldots\ldots\ldots 3.$$

$$K = 2.6024 + 0.00735(D) \ldots\ldots\ldots\ldots 4.$$

where: $\overline{X}$ is the arithmetic mean altitude; S.D. is the standard deviation from the mean; SK is the skewness of the altitude distribution; and K is the kurtosis value. D is the distance from base level, along streams, to the rock-topographic units, measured in Kilometers. The first equation defines land height relative to base level; the second notes the relief of the land. The other two equations describe the erosional setting.

4.3-(3) <u>The lithology-altitude relationship</u>:

(a)- At the Formation level, bedrock geology shows good correlation with arithmetic mean altitude. Volcanic igneous rocks stand lower than plutonic igneous; and higher than sedimentary rocks. The igneous rocks support topographies for which the arithmetic mean altitudes range in value according to the resistant-mineral content given in Bowen's reaction series. Sedimentary rocks stand in accordance with relative permeability: the most permeable, sandstones, stand higher than limestones, which stand higher than shales.

(b)- The relative erodibility of bedrock can be considered, using as a basis the arithmetic mean altitude of rock-topographic units, provided that the system in which the units are found is taken into account. In the thesis area, by adjusting for the effect of base level control of topography, a numerical relative scale of erodibilities is arrived at.

(c)- Of the factors which are thought to control the mean altitude of rock units in the western Gaspé system, the most important appears to be the nature of the internal fabric of the major constituent rock type of a given formation. The relative amount of interbedded weaker rocks (usually shale) is also important.

(d)- The degree of topographic control by influence of structural features, such as faults, is not known. Although there is some evidence from this study that thrust faults may be common in western Gaspé, it is expected from the observed overall trends of the altitude populations that differential erosion plays a greater role. At one possible fault locality, the north-front of the Big Berry Mountains, the great difference in relative erodibility of the Battery Point and Lake Branch formations seems to account adequately for the escarpment at their contact.

4.3-(4) Suggestions for further work.

In summary, this study is in nature a preliminary inquiry into the applicability of the method of frequency distribution analysis of altitude on the basis of lithology, as a way of describing topography. There is considerable potential in the method and room for considerable research. A more statistical approach might be taken. Model topographies might be analyzed. The same sort of study might be made with a variety of unit and sample sizes, and correlations attempted between several topographic areas, from different systems of erosion.

It would be interesting to compare results with other quantitative studies. The Gaspé is an ideal location for geomorphic research relating to landforms and topographic systems. The Fourier analysis of relief (Stone and Dugundji, 1963) or the fitting of three-dimensional landform equations (Troeh, 1965) might offer complimentary information.

The present study might have practical applications in photogeologic interpretation and mapping in the Gaspé, and possibly in the consideration of military geology (Wood and Snell, 1960; Kolb, 1962).

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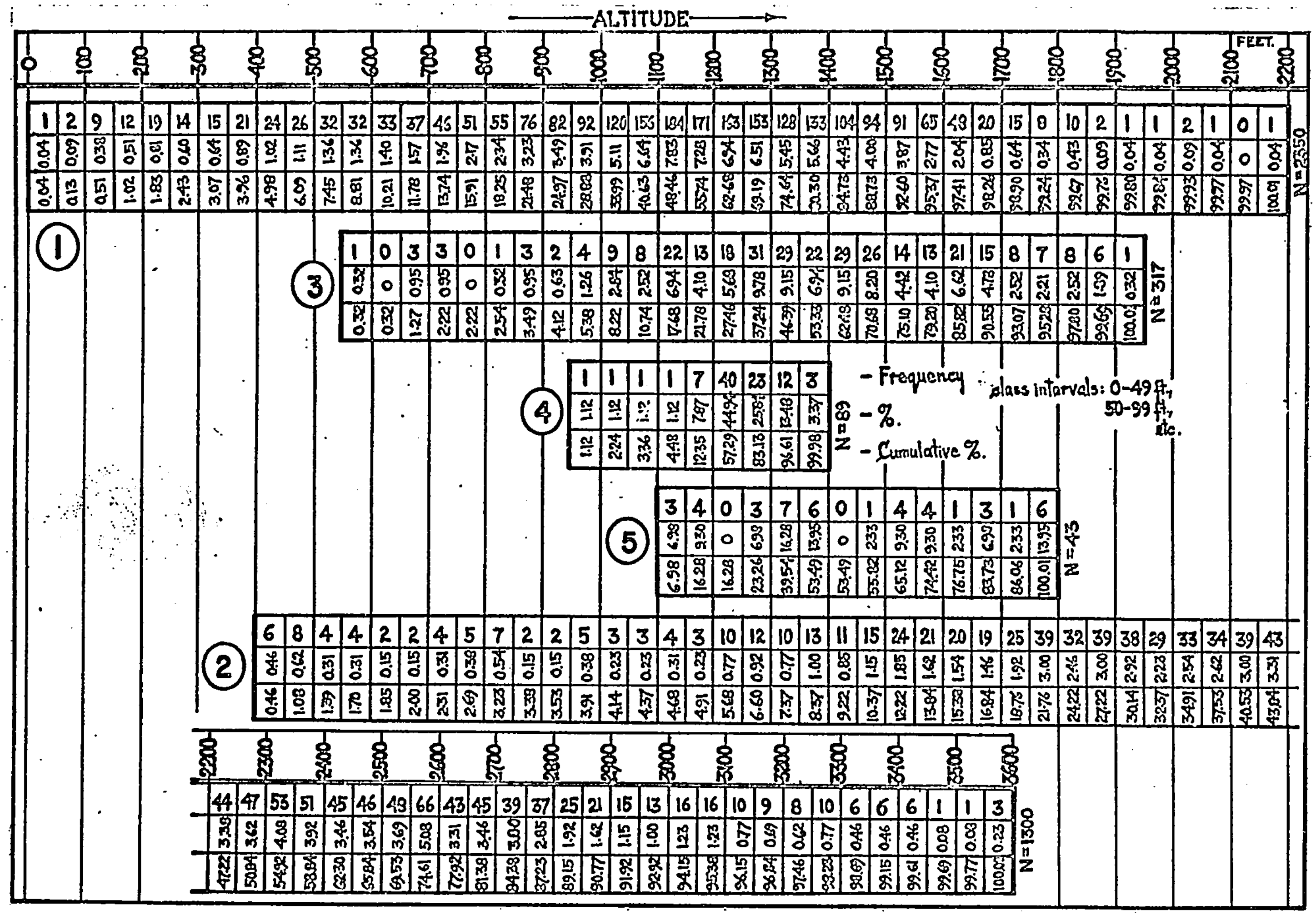
Ashley, G.H., and others, 1933, Classification and nomenclature of rock units: Geol. Soc. America Bull., v. 44, p. 423-459; Am. Assoc. Petroleum Geologists Bull., v. 17, p. 843-863; reprinted, 1939, ibid., v. 23, p. 1068-1088.

APPENDIX - A.

TABULATED Frequency distributions,
Percent frequency distributions,
Cumulative percent frequency distributions.



- Frequency
- %.
- Cumulative %.

class intervals: 0-49 ft, 50-99 ft, etc.

① N=2350

Frequency	%	Cumulative %
1	0.04	0.04
2	0.09	0.13
9	0.38	0.51
12	0.51	1.02
19	0.81	1.83
14	0.60	2.43
15	0.64	3.07
21	0.89	3.96
24	1.02	4.98
26	1.11	6.09
32	1.36	7.45
32	1.36	8.81
33	1.40	10.21
37	1.57	11.78
46	1.96	13.74
51	2.17	15.91
55	2.34	18.25
76	3.23	21.48
82	3.49	24.97
92	3.91	28.88
120	5.11	33.99
156	6.64	40.63
184	7.83	48.46
171	7.28	55.74
163	6.94	62.68
153	6.51	69.19
128	5.45	74.64
133	5.66	80.30
104	4.43	84.73
94	4.00	88.73
91	3.87	92.60
65	2.77	95.37
48	2.04	97.41
20	0.85	98.26
15	0.64	98.90
8	0.34	99.24
10	0.43	99.67
2	0.09	99.76
1	0.04	99.80
1	0.04	99.84
2	0.09	99.93
1	0.04	99.97
0	0	99.97
1	0.04	100.01

③ N=317

Frequency	%	Cumulative %
1	0.32	0.32
0	0	0.32
3	0.95	1.27
3	0.95	2.22
0	0	2.22
1	0.32	2.54
3	0.95	3.49
2	0.63	4.12
4	1.26	5.38
9	2.84	8.22
8	2.52	10.74
22	6.94	17.68
13	4.10	21.78
18	5.68	27.46
31	9.78	37.24
29	9.15	46.39
22	6.94	53.33
29	9.15	62.48
26	8.20	70.68
14	4.42	75.10
13	4.10	79.20
21	6.62	85.82
15	4.78	90.55
8	2.52	93.07
7	2.21	95.28
8	2.52	97.80
6	1.89	99.69
1	0.32	100.01

④ N=89

Frequency	%	Cumulative %
1	1.12	1.12
1	1.12	2.24
1	1.12	3.36
1	1.12	4.48
7	7.87	12.35
40	44.94	57.29
23	25.84	83.13
12	13.48	96.61
3	3.37	99.98

⑤ N=43

Frequency	%	Cumulative %
3	6.98	6.98
4	9.30	16.28
0	0	16.28
3	6.98	23.26
7	16.28	39.54
6	13.95	53.49
0	0	53.49
1	2.33	55.82
4	9.30	65.12
4	9.30	74.42
1	2.33	76.75
3	6.97	83.73
1	2.33	86.06
6	13.95	100.01

② N=1300

Frequency	%	Cumulative %
6	0.46	0.46
8	0.62	1.08
4	0.31	1.39
4	0.31	1.70
2	0.15	1.85
2	0.15	2.00
4	0.31	2.31
5	0.38	2.69
7	0.54	3.23
2	0.15	3.38
2	0.15	3.53
5	0.38	3.91
3	0.23	4.14
3	0.23	4.37
4	0.31	4.68
3	0.23	4.91
10	0.77	5.68
12	0.92	6.60
10	0.77	7.37
13	1.00	8.37
11	0.85	9.22
15	1.15	10.37
24	1.85	12.22
21	1.62	13.84
20	1.54	15.38
19	1.46	16.84
25	1.92	18.76
39	3.00	21.76
32	2.46	24.22
39	3.00	27.22
38	2.92	30.14
29	2.23	32.37
33	2.54	34.91
34	2.62	37.53
39	3.00	40.53
43	3.31	43.84
44	3.38	47.22
47	3.62	50.84
53	4.08	54.92
51	3.92	58.84
45	3.46	62.30
46	3.54	65.84
48	3.69	69.53
66	5.08	74.61
43	3.31	77.92
45	3.46	81.38
39	3.00	84.38
37	2.85	87.23
25	1.92	89.15
21	1.62	90.77
15	1.15	91.92
13	1.00	92.92
16	1.23	94.15
16	1.23	95.38
10	0.77	96.15
9	0.69	96.84
8	0.62	97.46
10	0.77	98.23
6	0.46	98.69
6	0.46	99.15
6	0.46	99.61
1	0.08	99.69
1	0.08	99.77
3	0.23	100.00

Table A-1. — Grouped data of frequency distributions for MOUNT LOGAN sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

ALTITUDE →

FEET: 1800 – 1900 – 2000 – 2100 – 2200 – 2300 – 2400 – 2500 – 2600 – 2700 – 2800 – 2900 – 3000 – 3100 – 3200 – 3300 – 3400 – 3500 – 3600 – 3700 – 3800 – 3900 – 4000 – 4100

①

900 – 1000 – 1100 – 1200 – 1300 – 1400 – 1500 – 1600 – 1700 – 1800

class intervals: 0-49 ft., 50-99 ft. etc.

Frequency	%	Cumulative %
1	0.60	0.60
0	0	0.60
0	0	0.60
0	0	0.60
0	0	0.60
1	0.60	1.20
0	0	1.20
1	0.60	1.80
1	0.60	2.40
0	0	2.40
0	0	2.40
0	0	2.40
0	0	2.40
0	0	2.40
5	3.01	5.41
1	0.60	6.01
3	1.81	7.82
1	0.60	8.42

2	1.20	9.62
1	0.60	10.22
3	1.81	12.03
3	1.81	13.84
0	0	13.84
4	2.41	16.25
4	2.41	18.66
1	0.60	19.26
2	1.20	20.46
4	2.41	22.87
3	1.81	24.68
4	2.41	27.09
7	4.22	31.31
3	1.81	33.12
3	1.81	34.93
5	3.01	37.94
5	3.01	40.95
3	1.81	42.76
4	2.41	45.17
3	1.81	46.98
4	2.41	49.39
4	2.41	51.80
3	1.81	53.61
2	1.20	54.81
3	1.81	56.62
4	2.41	59.03
4	2.41	61.44
4	2.41	63.85
6	3.61	67.46
2	1.20	68.66
7	4.22	72.88
10	6.02	78.90
9	5.42	84.32
9	5.42	89.74
4	2.41	92.15
3	1.81	93.96
3	1.81	95.77
4	2.41	98.18
2	1.20	99.38
1	0.60	99.98

N = 166

②

1	0.21	0.21
0	0	0.21
3	0.64	0.85
3	0.64	1.49
4	0.86	2.35
2	0.43	2.78
2	0.43	3.21
4	0.86	4.07
3	0.64	4.71
7	1.49	6.20
10	2.14	8.34
5	1.07	9.41
7	1.49	10.90
6	1.28	12.18
6	1.28	13.46
12	2.57	16.03
7	1.49	17.52
14	3.00	20.52
8	1.71	22.23
11	2.36	24.59
3	0.64	25.23
9	1.93	27.16
10	2.14	29.30
7	1.49	30.79
10	2.14	32.93
16	3.43	36.36
23	4.93	41.29
33	7.07	48.36
26	5.57	53.93
29	6.21	60.14
26	5.57	65.71
26	5.57	71.28
37	7.92	79.20
21	4.50	83.70
13	2.78	86.48
17	3.64	90.12
12	2.57	92.69
9	1.93	94.62
3	0.64	95.26
5	1.07	96.33
4	0.86	97.19
6	1.28	98.47
3	0.64	99.11
2	0.43	99.54
2	0.43	99.97

N = 467

②A

1	0.65	0.65
0	0	0.65
3	1.96	2.61
3	1.96	4.57
4	2.61	7.18
2	1.31	8.49
2	1.31	9.80
4	2.61	12.41
3	1.96	14.37
7	4.58	18.95
10	6.54	25.49
5	3.27	28.76
7	4.58	33.34
6	3.92	37.26
6	3.92	41.18
12	7.84	49.02
5	3.27	52.29
12	7.84	60.13
7	4.98	64.71
7	4.58	69.29
3	1.96	71.25
7	4.58	75.83
4	2.61	78.44
4	2.61	81.05
5	3.27	84.32
6	3.92	88.24
7	4.58	92.82
2	1.31	94.13
2	1.31	95.44
1	0.65	96.09
0	0	96.09
1	0.65	96.74
1	0.65	97.39
3	1.96	99.35
1	0.65	100.00

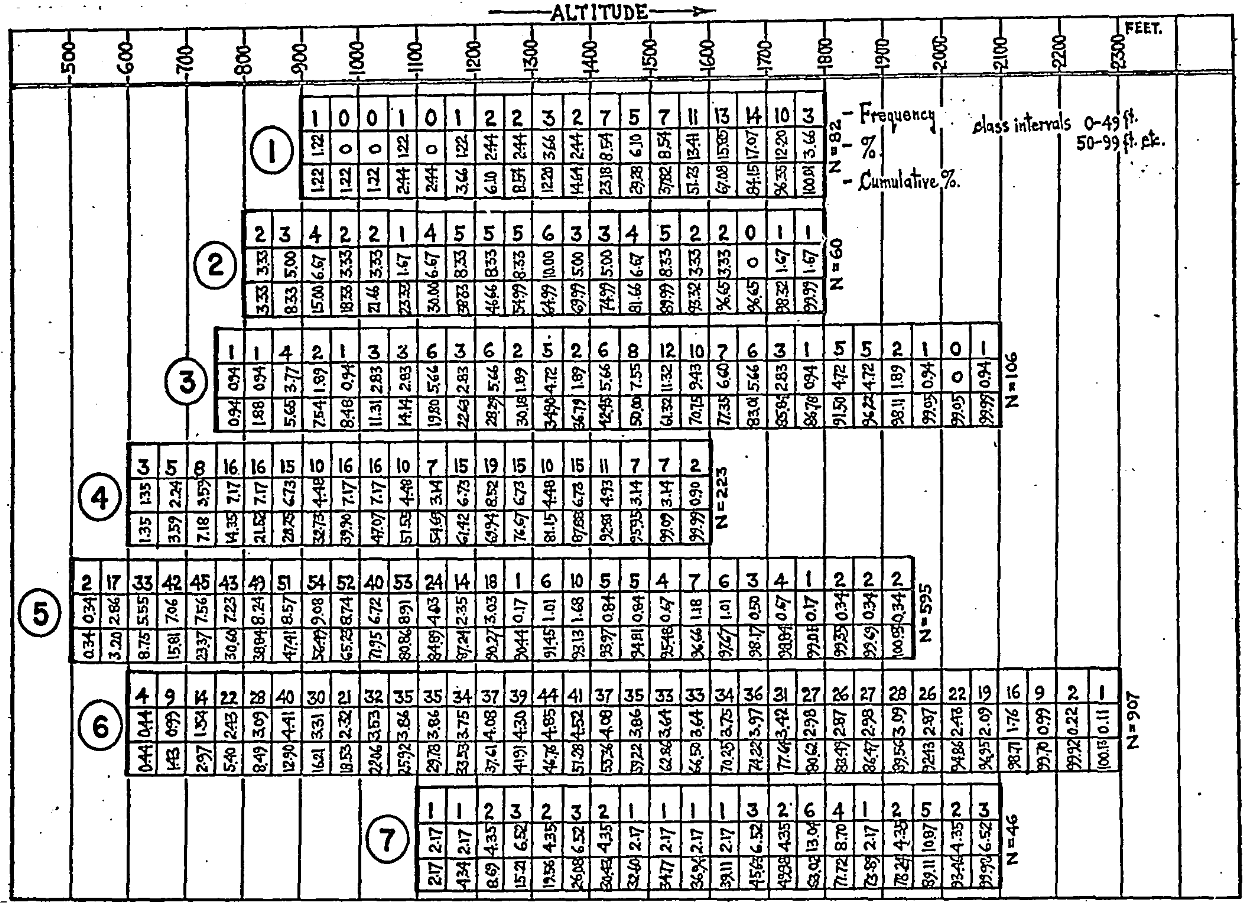
N = 153

②B

2	0.64	0.64
2	0.64	1.28
1	0.32	1.60
4	1.27	2.87
0	0.0	2.87
2	0.64	3.51
6	1.91	5.42
3	0.96	6.38
5	1.59	7.97
10	3.18	11.15
16	5.10	16.25
31	9.87	26.12
24	7.64	33.76
28	8.92	42.68
26	8.28	50.96
25	7.96	58.92
36	11.46	70.38
18	5.73	76.11
12	3.82	79.93
17	5.41	85.34
12	3.82	89.16
9	2.87	92.03
3	0.96	92.99
5	1.59	94.58
4	1.27	95.85
6	1.91	97.76
3	0.96	98.72
2	0.64	99.36
2	0.64	100.00

N = 314

Table A-2.— Grouped data of frequency distributions for MONT ALBERT & TABLETOP sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.



①

1	0	0	1	0	1	2	2	3	2	7	5	7	11	13	14	10	3
1.22	0	0	1.22	0	1.22	2.44	2.44	3.66	2.44	8.54	6.10	8.54	13.41	15.85	17.07	12.20	3.66
1.22	1.22	1.22	2.44	2.44	3.66	6.10	8.54	12.20	14.64	23.18	29.28	37.82	51.23	67.08	84.15	96.35	100.01

N=82

②

2	3	4	2	2	1	4	5	5	5	6	3	3	4	5	2	2	0	1	1
3.33	5.00	6.67	3.33	3.33	1.67	6.67	8.33	8.33	8.33	10.00	5.00	5.00	6.67	8.33	3.33	3.33	0	1.67	1.67
3.33	8.33	15.00	18.33	21.66	23.33	30.00	38.33	46.66	54.99	64.99	69.99	74.99	81.66	89.99	93.32	96.65	96.65	98.32	99.99

N=60

③

1	1	4	2	1	3	3	6	3	6	2	5	2	6	8	12	10	7	6	3	1	5	5	2	1	0	1
0.94	0.94	3.77	1.89	0.94	2.83	2.83	5.66	2.83	5.66	1.89	4.72	1.89	5.66	7.55	11.32	9.43	6.60	5.66	2.83	0.94	4.72	4.72	1.89	0.94	0	0.94
0.94	1.88	5.65	7.54	8.48	11.31	14.14	19.80	22.63	28.29	30.18	34.90	36.79	42.45	50.00	61.32	70.75	77.35	83.01	85.84	86.78	91.50	96.22	98.11	99.05	99.05	99.99

N=106

④

3	5	8	16	16	15	10	16	16	10	7	15	19	15	10	15	11	7	7	2
1.35	2.24	3.59	7.17	7.17	6.73	4.48	7.17	7.17	4.48	3.14	6.73	8.52	6.73	4.48	6.73	4.93	3.14	3.14	0.90
1.35	3.59	7.18	14.35	21.52	28.25	32.73	39.90	47.07	51.55	54.69	61.42	69.94	76.67	81.15	87.88	92.81	95.95	99.09	99.99

N=223

⑤

2	17	33	42	45	43	49	51	54	52	40	53	24	14	18	1	6	10	5	5	4	7	6	3	4	1	2	2	2
0.34	2.86	5.55	7.06	7.56	7.23	8.24	8.57	9.08	8.74	6.72	8.91	4.03	2.35	3.03	0.17	1.01	1.68	0.84	0.84	0.67	1.18	1.01	0.50	0.67	0.17	0.34	0.34	0.34
0.34	3.20	8.75	15.81	23.37	30.60	38.84	47.41	56.49	65.23	71.95	80.86	84.89	87.24	90.27	90.44	91.45	93.13	93.97	94.81	95.48	96.66	97.67	98.17	98.84	99.01	99.35	99.69	100.03

N=595

⑥

4	9	14	22	28	40	30	21	32	35	35	34	37	39	44	41	37	35	33	33	34	36	31	27	26	27	28	26	22	19	16	9	2	1
0.44	0.99	1.54	2.43	3.09	4.41	3.31	2.32	3.53	3.86	3.86	3.75	4.08	4.30	4.85	4.52	4.08	3.86	3.64	3.64	3.75	3.97	3.42	2.98	2.87	2.98	3.09	2.87	2.48	2.09	1.76	0.99	0.22	0.11
0.44	1.43	2.97	5.40	8.49	12.90	16.21	18.53	22.06	25.92	29.78	33.53	37.61	41.91	46.76	51.28	55.36	59.22	62.86	66.50	70.25	74.22	77.64	80.62	83.49	86.47	89.56	92.43	94.86	96.95	98.71	99.70	99.92	100.13

N=907

⑦

1	1	2	3	2	3	2	1	1	1	1	3	2	6	4	1	2	5	2	3
2.17	2.17	4.35	6.52	4.35	6.52	4.35	2.17	2.17	2.17	2.17	6.52	4.35	13.04	8.70	2.17	4.35	10.87	4.35	6.52
2.17	4.34	8.69	15.21	19.56	26.08	30.43	32.60	34.77	36.94	39.11	45.63	49.98	63.02	71.72	73.89	78.24	89.11	93.46	99.98

N=46

Table A-3a. — Grouped data of frequency distributions for BIG BERRY MTNS. WEST sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

ALTITUDE →

500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 FEET.

- Frequency
- %.
- Cumulative %.

class intervals: 0-49 ft.
50-99 ft. etc.

5A

2	2	4	6	8	13	17	18	9	7	6	1	6	10	4	5	4	7	6	3	4	1	2	2	2
1.34	1.34	2.68	4.03	5.37	8.72	11.41	12.08	6.04	4.70	4.03	0.67	4.03	6.71	2.68	3.36	2.68	4.70	4.03	2.01	2.68	0.67	1.34	1.34	1.34
1.34	2.68	5.36	9.39	14.76	23.48	34.89	46.97	53.01	57.71	61.74	62.41	66.44	73.15	75.83	79.19	81.87	86.57	90.60	92.61	95.29	95.96	97.30	98.64	99.98

N = 149

5B

3	12	8	13	14	19	21	17	14	11	16	6	2	6
1.85	7.41	4.94	8.02	8.64	11.73	12.96	10.49	8.64	6.79	9.88	3.70	1.23	3.70
1.85	9.26	14.20	22.22	30.86	42.59	55.55	66.04	74.68	81.47	91.35	95.05	96.28	99.98

N = 162

5C

6	10	16	15	19	15	18	21	14	9	11	6	5	5
3.53	5.88	9.41	8.82	11.18	8.82	10.59	12.35	8.24	5.29	6.47	3.53	2.94	2.94
3.53	9.41	18.82	27.64	38.82	47.64	58.23	70.58	78.82	84.11	90.58	94.11	97.05	99.99

N = 170

5D

2	8	11	18	15	8	11	6	8	11	3	8	3	0	1	0	0	0	1
1.75	7.02	9.65	15.79	13.16	7.02	9.65	5.26	7.02	9.65	2.63	7.02	2.63	0.0	0.88	0.0	0.0	0.0	0.88
1.75	8.77	18.42	34.21	47.37	54.39	64.04	69.30	76.32	85.97	88.60	95.62	98.25	98.25	99.13	99.13	99.13	99.13	100.01

N = 114

Table A-3b.— Grouped data of frequency distributions for part of BIG BERRY MOUNTAINS WEST sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

ALTITUDE (FEET.)	①			②			③			④			⑤			⑥		
	Frequency	%	Cumulative %	Frequency	%	Cumulative %	Frequency	%	Cumulative %	Frequency	%	Cumulative %	Frequency	%	Cumulative %	Frequency	%	Cumulative %
							3	0.34	0.34	1	0.39	0.39						
100							10	1.15	1.49	0	0	0.39						
							7	0.80	2.29	0	0	0.39	6	4.14	4.14	2	0.46	0.46
200							15	1.72	3.91	2	0.78	1.17	1	0.69	4.83	0	0	0.46
							8	0.92	4.83	2	0.78	1.95	6	4.14	8.97	0	0	0.46
300				1	0.33	0.33	7	0.80	5.63	1	0.39	2.34	0	0	8.97	1	0.78	0.69
				0	0	0.33	8	0.92	6.55	2	0.78	3.12	2	1.38	10.35	2	0.78	1.15
400				0	0	0.33	10	1.15	7.70	4	1.56	4.68	5	3.45	13.80	6	0.39	2.52
				0	0	0.33	8	0.92	8.62	2	0.78	5.46	3	2.07	15.87	3	0.78	3.20
500				1	0.33	0.66	9	1.03	9.65	6	2.34	7.80	5	3.45	19.32	4	1.56	4.11
				3	1.00	1.66	13	1.49	11.14	6	2.34	10.14	4	2.76	22.08	6	0.78	5.48
600				0	0	1.66	12	1.37	12.51	2	0.78	10.92	10	6.90	28.98	3	2.34	6.16
				1	0.33	1.99	20	2.29	14.80	4	1.56	12.48	7	4.83	33.81	6	2.34	7.53
700				4	1.33	3.32	11	1.26	16.06	3	1.17	13.65	9	6.21	40.02	11	0.78	10.04
				1	0.33	3.65	13	1.49	17.55	3	1.17	14.82	13	8.97	48.99	8	1.56	11.86
800				7	2.33	5.98	13	1.49	19.04	7	2.73	17.55	8	5.62	54.51	6	1.37	13.23
				0	0	5.98	11	1.26	20.30	6	2.34	19.89	9	6.21	60.72	6	1.37	14.60
900				3	1.00	6.98	15	1.72	22.02	10	3.91	23.80	10	6.90	67.62	5	1.14	15.74
				6	1.99	8.97	15	1.72	23.74	8	3.13	26.93	4	2.76	70.38	9	2.05	17.79
1000				8	2.66	11.63	26	2.98	26.72	15	5.86	32.79	9	6.21	76.59	10	2.28	20.07
	1	1.69	1.69	13	4.32	15.95	28	3.21	29.93	8	3.13	35.92	5	3.45	80.04	15	3.42	23.49
1100	2	3.39	5.08	7	2.33	18.28	33	3.78	33.71	14	5.47	41.39	4	2.76	82.80	10	2.28	25.77
	1	1.69	6.77	9	2.99	21.27	24	2.75	36.46	24	9.38	50.77	6	4.14	86.94	18	4.10	29.87
1200	3	5.08	11.85	11	3.65	24.92	36	4.12	40.58	24	9.38	60.15	9	6.21	93.15	24	5.47	35.34
	0	0	11.85	13	4.32	29.24	34	3.89	44.47	23	8.98	69.13	4	2.76	95.91	21	4.78	40.12
1300	3	5.08	16.93	10	3.32	32.56	46	5.27	49.74	18	7.03	76.16	2	1.38	97.29	22	5.01	45.13
	0	0	16.93	15	4.98	37.54	52	5.96	55.70	19	7.42	83.58	1	0.69	97.98	34	7.74	52.87
1400	3	5.08	22.01	18	5.98	43.52	64	7.33	63.03	13	5.08	88.66	3	2.07	100.05	27	6.15	59.02
	2	3.39	25.40	17	5.65	49.17	63	7.22	70.25	14	5.47	94.13				28	6.38	65.40
1500	6	10.17	35.57	15	4.98	54.15	62	7.10	77.35	5	1.95	96.08				32	7.29	72.69
	2	3.39	38.96	15	4.98	59.13	55	6.30	83.65	5	1.95	98.03				35	7.97	80.66
1600	4	6.78	45.74	16	5.32	64.45	46	5.27	88.92	5	1.95	99.98				17	3.87	84.53
	2	3.39	49.13	20	6.64	71.09	45	5.15	94.07							17	3.87	88.40
1700	2	3.39	52.52	19	6.31	77.40	23	2.63	96.70							20	4.56	92.96
	2	3.39	55.91	14	4.65	82.05	16	1.83	98.53							12	2.73	95.69
1800	6	10.17	66.08	12	3.99	86.04	10	1.15	99.68							6	1.37	97.06
	4	6.78	72.86	8	2.66	88.70	2	0.23	99.91							11	2.51	99.57
1900	4	6.78	79.64	4	1.33	90.03										1	0.23	99.80
	2	3.39	83.03	7	2.33	92.36										1	0.23	100.03
2000	5	8.47	91.50	3	1.00	93.36												
	4	6.78	98.28	3	1.00	94.36												
2100	1	1.69	99.97	6	1.99	96.35												
				3	1.00	97.35												
2200				3	1.00	98.35												
				1	0.33	98.68												
2300				1	0.33	99.01												
				0	0	99.01												
2400				3	1.00	100.01												
	N=59			N=301			N = 873			N=256			N=145			N=439		

class intervals: 0-49 ft., 50-99 ft., etc.

Table A-4. — Grouped data of frequency distributions for RIVIÈRE ANGERS, EAST sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

ALTITUDE →

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 FEET.

①

N = 945

1	3	3	3	3	12	8	9	6	15	18	20	16	16	23	24	21	25	29	33	58	62	57	45	58	54	43	26	30	32	37	23	21	29	26	21	12	9	12	2
0.11	0.32	0.32	0.32	0.32	1.27	0.85	0.95	0.63	1.59	1.90	2.12	1.69	1.69	2.43	2.54	2.22	2.65	3.07	3.49	6.14	6.56	6.03	4.76	6.14	5.71	4.55	2.75	3.17	3.39	3.92	2.43	2.22	3.07	2.75	2.22	1.27	0.95	1.27	0.21
0.11	0.43	0.75	1.07	1.39	2.66	3.51	4.46	5.09	6.68	8.58	10.70	12.39	14.08	16.51	19.05	21.27	23.92	26.99	30.48	36.62	43.18	49.21	53.97	60.11	65.82	70.37	73.12	76.29	79.68	83.60	86.03	88.25	91.32	94.07	96.29	97.56	98.51	99.78	99.99

(1A)

N = 202

1	0	0	1	1	0	0	0	3	2	1	4	5	2	3	10	13	11	27	29	21	12	12	18	13	7	5	1
0.50	0	0	0.50	0.50	0	0	0	1.49	0.99	0.50	1.98	2.48	0.99	1.49	4.95	6.44	5.45	13.37	14.36	10.40	5.94	5.94	8.91	6.44	3.47	2.48	0.50
0.50	0.50	0.50	1.00	1.50	1.50	1.50	1.50	2.99	3.98	4.48	6.48	8.94	9.93	11.42	16.37	22.81	28.26	41.63	55.99	66.39	72.33	78.27	87.18	93.62	97.09	99.57	100.07

- Frequency
- %.
- Cumulative %.

class intervals: 0-49 ft,
50-99 ft,
etc

②

N = 491

1	14	12	9	11	16	10	14	18	13	10	22	18	20	29	35	54	45	52	34	24	17	9	2	2
0.20	2.85	2.44	1.83	2.24	3.26	2.04	2.85	3.67	2.65	2.04	4.48	3.67	4.07	5.91	7.13	11.00	9.16	10.59	6.92	4.89	3.46	1.85	0.41	0.41
0.20	3.05	5.49	7.32	9.56	12.82	14.86	17.71	21.38	24.03	26.07	30.55	34.22	38.29	44.20	51.33	62.33	71.49	82.08	89.00	93.89	97.35	99.18	99.59	100.00

③

N = 261

14	25	21	16	18	7	14	11	8	14	15	16	15	11	14	10	12	10	4	5	0	1
5.36	9.58	8.05	6.13	6.90	2.68	5.36	4.21	3.07	5.36	5.75	6.13	5.75	4.21	5.36	3.83	4.60	3.83	1.53	1.92	0	0.38
5.36	14.94	22.99	29.12	36.02	38.70	44.06	48.27	51.34	56.70	62.45	68.58	74.33	78.54	83.90	87.73	92.33	96.16	97.69	99.61	99.61	99.99

Table A-5. – Grouped data of frequency distributions for ESCUMINAC sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

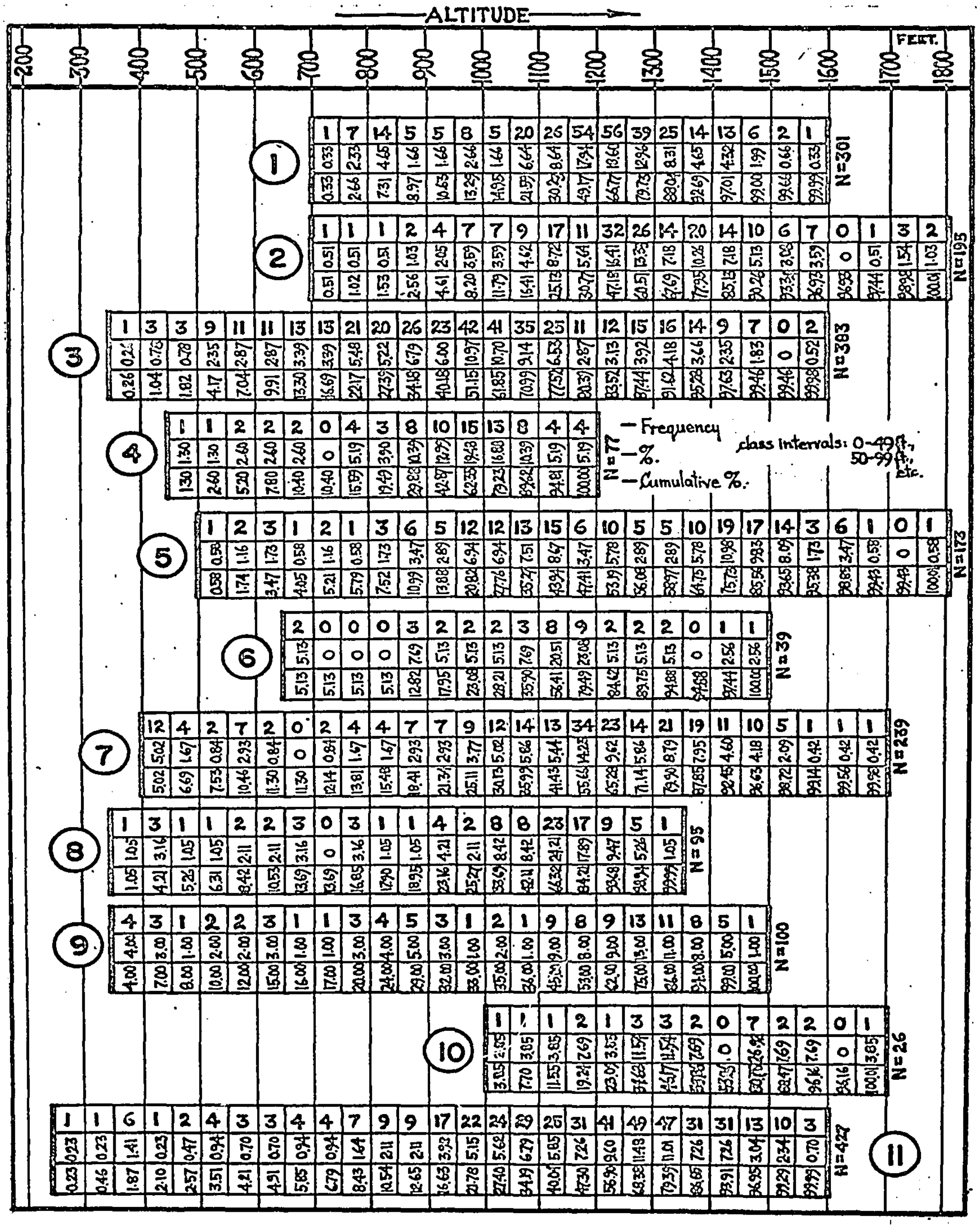
Appendix-A

ALTITUDE	0		100		200		300		400		500		600		700		800		900		1000		1100		1200		1300		1400		1500		1600		1700 FEET	
①										2	3	7	3	6	7	6	5	7	7	9	14	14	20	10	14	15	16	7	4	4						
										1.11	1.67	3.89	1.67	3.33	3.89	3.33	2.78	3.89	3.89	5.00	7.78	7.78	11.11	5.56	7.78	8.33	8.89	3.89	2.22	2.22						
N=180										1.11	2.78	6.67	8.34	11.67	15.56	18.89	21.67	25.56	29.45	34.45	42.23	50.01	61.12	66.68	74.46	82.79	91.68	95.57	97.79	100.01						
②													1	1	3	0	5	4	2	8	11	14	27	32	15	34	29	31	17	18	18	11	5	1	2	
													0.35	0.35	1.04	0	1.73	1.38	0.69	2.77	3.80	4.84	9.34	11.07	5.19	11.76	10.03	10.73	5.88	6.23	6.23	3.80	1.73	0.35	0.69	
N=289													0.35	0.70	1.74	1.74	3.47	4.85	5.54	8.31	12.11	16.95	26.29	37.36	42.55	54.31	64.34	75.07	80.95	87.18	93.41	97.21	98.94	99.29	99.98	
③						1	0	0	0	0	1	1	3	7	5	5	6	8	14	17	20	18	31	43	56	57	65	80	62	42	36	17	13	6	5	1
						0.16	0	0	0	0	0.16	0.16	0.48	1.13	0.81	0.81	0.97	1.29	2.26	2.74	3.23	2.90	5.00	6.94	9.03	9.19	10.48	12.90	10.00	6.77	5.81	2.74	2.10	0.97	0.81	0.16
N=621						0.16	0.16	0.16	0.16	0.16	0.32	0.48	0.96	2.09	2.90	3.71	4.68	5.97	8.23	10.97	14.20	17.10	22.10	29.04	38.07	47.26	57.74	70.64	80.64	87.41	93.22	95.96	98.06	99.03	99.84	100.00
④										1	3	3	9	3	7	12	10	13	32	34	41	45	55	44	60	59	35	26	19	13	10	3	2	1		
										0.19	0.58	0.58	1.73	0.58	1.35	2.31	1.92	2.50	6.15	6.54	7.88	8.65	10.58	8.46	11.54	7.50	6.73	5.00	3.65	2.50	1.92	0.58	0.58	0.19		
N=520										0.19	0.77	1.35	3.08	3.66	5.01	7.32	9.24	11.74	17.69	24.43	32.31	40.96	51.54	60.00	71.54	79.04	85.77	90.77	94.42	96.92	98.84	99.42	99.80	99.99		
⑤		1	2	2	4	10	12	21	24	40	33	27	34	49	57	70	103	97	123	128	115	77	45	11	6											
		0.09	0.18	0.18	0.37	0.92	1.10	1.92	2.20	3.67	3.02	2.47	3.12	4.49	5.22	6.42	9.44	8.89	11.27	11.73	10.54	7.06	4.12	1.01	0.55											
N=1091		0.09	0.27	0.45	0.82	1.74	2.84	4.76	6.96	10.63	13.65	16.12	19.24	23.73	28.95	35.37	44.81	53.70	64.97	76.70	87.24	94.30	98.42	99.43	99.98											
⑥	8	3	10	13	22	22	24	24	14	19	21	18	21	22	13	23	29	16	26	23	15	17	16	12	11	5	2	1								
	1.78	0.67	2.22	2.89	4.89	4.89	5.33	5.33	3.11	4.22	4.67	4.00	4.67	4.89	2.89	5.11	6.44	3.56	5.78	5.11	3.33	3.78	3.56	2.67	2.44	1.11	0.44	0.22								
N=450	1.78	2.45	4.67	7.56	12.45	17.34	22.67	28.00	31.11	35.33	40.00	44.00	48.67	53.56	56.45	61.56	68.00	71.56	77.34	82.45	85.78	89.56	93.12	95.79	98.23	99.34	99.78	100.00								
⑦	11	12	11	8	10	9	18	22	21	20	19	18	15	16	20	22	26	23	15	20	24	12	26	7	8	7	6	2	1	1	1	0	1			
	2.55	2.78	2.55	1.85	2.31	2.08	4.17	5.09	4.86	4.63	4.40	4.17	3.47	3.70	4.63	5.09	6.02	5.32	3.47	4.63	5.55	2.78	6.02	1.62	1.85	1.62	1.39	0.46	0.23	0.23	0.23	0	0.23			
N=432	2.55	5.33	7.88	9.73	12.04	14.12	18.29	23.38	28.24	32.87	37.27	41.44	44.91	48.61	53.24	58.33	64.35	69.67	73.14	77.77	83.32	86.10	92.12	93.74	95.59	97.21	98.60	99.06	99.29	99.52	99.78	99.75	99.98			
6A	8	3	9	10	20	12	15	15	9	12	13	11	10	12	6	8	11	5	9	6	4	3	5	1	6	1										
	3.57	1.34	4.02	4.46	8.93	5.36	6.70	6.70	4.02	5.36	5.80	4.91	4.46	5.36	2.68	3.57	4.91	2.23	4.02	2.68	1.79	1.34	2.23	0.45	2.68	0.45										
N=224	3.57	4.91	8.93	13.39	22.32	27.68	34.38	41.08	45.10	50.46	56.26	61.17	65.63	70.99	73.67	77.24	82.15	84.38	88.40	91.08	92.87	94.21	96.44	96.89	99.57	100.02										
6B			1	3	2	10	9	9	5	7	8	7	11	10	7	15	18	11	17	17	11	14	11	11	5	4	2	1								
			0.44	1.33	0.88	4.42	3.98	3.98	2.21	3.10	3.54	3.10	4.87	4.42	3.10	6.64	7.96	4.87	7.52	7.52	4.87	6.19	4.87	4.87	2.21	1.77	0.88	0.44								
N=226			0.44	1.77	2.65	7.07	11.05	15.03	17.24	20.34	23.88	26.98	31.85	36.27	39.37	46.01	53.97	58.84	66.36	73.88	78.75	84.94	89.81	94.68	96.89	98.66	99.54	99.98								
7A	10	9	7	2	6	2	9	9	11	10	9	6	6	8	9	6	9	9	3	3	1															
	6.94	6.25	4.89	1.39	4.17	1.39	6.25	6.25	7.64	6.94	6.25	4.17	4.17	5.56	6.25	4.17	6.25	6.25	2.08	2.08	0.69															
N=144	6.94	13.19	18.05	19.44	23.61	25.00	31.25	37.50	45.14	52.08	58.33	62.50	66.67	72.23	78.48	82.65	88.90	95.15	97.23	99.31	100.00															
7B	1	3	4	6	4	7	9	13	10	10	10	12	9	8	11	16	17	14	12	17	23	12	26	7	8	7	6	2	1	1	1	0	1			
	0.35	1.04	1.39	2.08	1.39	2.43	3.13	4.51	3.47	3.47	3.47	4.17	3.13	2.78	3.82	5.56	5.90	4.86	4.17	5.90	7.99	4.17	9.03	2.43	2.78	2.43	2.08	0.69	0.35	0.35	0.35	0	0.35			
N=288	0.35	1.39	2.78	4.86	6.25	8.68	11.81	16.32	19.79	23.26	26.73	30.90	34.03	36.81	40.63	46.19	52.09	56.95	61.12	67.02	75.01	79.18	88.21	90.64	93.42	95.85	97.93	98.62	98.97	99.32	99.67	99.67	100.02			

- Frequency
- %.
- Cumulative %.

class intervals: 0-49ft, 50-99ft, etc.

Table A-6.— Grouped data of frequency distributions for OAK BAY sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.



— Frequency
— %.
— Cumulative %.

class intervals: 0-49 ft., 50-99 ft., etc.

① N=301

Frequency	%	Cumulative %
1	0.33	0.33
7	2.33	2.66
14	4.65	7.31
5	1.66	8.97
5	1.66	10.63
8	2.66	13.29
5	1.66	14.95
20	6.64	21.59
26	8.64	30.23
54	17.94	49.17
56	18.60	67.77
39	12.96	79.73
25	8.31	88.04
14	4.65	92.69
13	4.32	97.01
6	1.99	99.00
2	0.66	99.66
1	0.33	99.99

② N=195

Frequency	%	Cumulative %
1	0.51	0.51
1	0.51	1.02
1	0.51	1.53
2	1.03	2.56
4	2.05	4.61
7	3.59	8.20
7	3.59	11.79
9	4.62	16.41
17	8.72	25.13
11	5.64	30.77
32	16.41	47.18
26	13.33	60.51
14	7.18	67.69
20	10.26	77.95
14	7.18	85.13
10	5.13	90.26
6	3.08	93.34
7	3.59	96.93
0	0	96.93
1	0.51	97.44
3	1.54	98.98
2	1.03	100.01

③ N=383

Frequency	%	Cumulative %
1	0.26	0.26
3	0.78	1.04
3	0.78	1.82
9	2.35	4.17
11	2.87	7.04
11	2.87	9.91
13	3.39	13.30
13	3.39	16.69
21	5.48	22.17
20	5.22	27.39
26	6.79	34.18
23	6.00	40.18
42	10.97	51.15
41	10.70	61.85
35	9.14	70.99
25	6.53	77.52
11	2.87	80.39
12	3.13	83.52
15	3.92	87.44
16	4.18	91.62
14	3.66	95.28
9	2.35	97.63
7	1.83	99.46
0	0	99.46
2	0.52	99.98

④ N=77

Frequency	%	Cumulative %
1	1.30	1.30
1	1.30	2.60
2	2.60	5.20
2	2.60	7.80
2	2.60	10.40
0	0	10.40
4	5.19	15.59
3	3.90	19.49
8	10.39	29.88
10	12.99	42.87
15	19.48	62.35
13	16.88	79.23
8	10.39	89.62
4	5.19	94.81
4	5.19	100.00

⑤ N=173

Frequency	%	Cumulative %
1	0.58	0.58
2	1.16	1.74
3	1.73	3.47
1	0.58	4.05
2	1.16	5.21
1	0.58	5.79
3	1.73	7.52
6	3.47	10.99
5	2.89	13.88
12	6.94	20.82
12	6.94	27.76
13	7.51	35.27
15	8.67	43.94
6	3.47	47.41
10	5.78	53.19
5	2.89	56.08
5	2.89	58.97
10	5.78	64.75
19	10.98	75.73
17	9.83	85.56
14	8.09	93.65
3	1.73	95.38
6	3.47	98.85
1	0.58	99.43
0	0	99.43
1	0.58	100.01

⑥ N=39

Frequency	%	Cumulative %
2	5.13	5.13
0	0	5.13
0	0	5.13
0	0	5.13
3	7.69	12.82
2	5.13	17.95
2	5.13	23.08
2	5.13	28.21
3	7.69	35.90
8	20.51	56.41
9	23.08	79.49
2	5.13	84.62
2	5.13	89.75
2	5.13	94.88
0	0	94.88
1	2.56	97.44
1	2.56	100.00

⑦ N=239

Frequency	%	Cumulative %
12	5.02	5.02
4	1.67	6.69
2	0.84	7.53
7	2.93	10.46
2	0.84	11.30
0	0	11.30
2	0.84	12.14
4	1.67	13.81
4	1.67	15.48
7	2.93	18.41
7	2.93	21.34
9	3.77	25.11
12	5.02	30.13
14	5.86	35.99
13	5.44	41.43
34	14.23	55.66
23	9.62	65.28
14	5.86	71.14
21	8.79	79.90
19	7.95	87.85
11	4.60	92.45
10	4.18	96.63
5	2.09	98.72
1	0.42	99.14
1	0.42	99.56
1	0.42	99.98

⑧ N=95

Frequency	%	Cumulative %
1	1.05	1.05
3	3.16	4.21
1	1.05	5.26
1	1.05	6.31
2	2.11	8.42
2	2.11	10.53
3	3.16	13.69
0	0	13.69
3	3.16	16.85
1	1.05	17.90
1	1.05	18.95
4	4.21	23.16
2	2.11	25.27
8	8.42	33.69
8	8.42	42.11
23	24.21	66.32
17	17.89	84.21
9	9.47	93.68
5	5.26	98.94
1	1.05	99.99

⑨ N=100

Frequency	%	Cumulative %
4	4.00	4.00
3	3.00	7.00
1	1.00	8.00
2	2.00	10.00
2	2.00	12.00
3	3.00	15.00
1	1.00	16.00
1	1.00	17.00
3	3.00	20.00
4	4.00	24.00
5	5.00	29.00
3	3.00	32.00
1	1.00	33.00
2	2.00	35.00
1	1.00	36.00
9	9.00	45.00
8	8.00	53.00
9	9.00	62.00
13	13.00	75.00
11	11.00	86.00
8	8.00	94.00
5	5.00	99.00
1	1.00	100.00

⑩ N=26

Frequency	%	Cumulative %
1	3.85	3.85
1	3.85	7.70
1	3.85	11.55
2	7.69	19.24
1	3.85	23.09
3	11.57	34.62
3	11.54	46.17
2	7.69	53.86
0	0	53.86
7	26.92	80.78
2	7.69	88.47
2	7.69	96.16
0	0	96.16
1	3.85	100.01

⑪ N=427

Frequency	%	Cumulative %
1	0.23	0.23
1	0.23	0.46
6	1.41	1.87
1	0.23	2.10
2	0.47	2.57
4	0.94	3.51
3	0.70	4.21
3	0.70	4.91
4	0.94	5.85
4	0.94	6.79
7	1.64	8.43
9	2.11	10.54
9	2.11	12.65
17	3.98	16.63
22	5.15	21.78
24	5.62	27.40
29	6.79	34.19
25	5.85	40.04
31	7.26	47.30
41	9.60	56.90
49	11.48	68.38
47	11.01	79.39
31	7.26	86.65
31	7.26	93.91
13	3.04	96.95
10	2.34	99.29
3	0.70	99.99

Table A-7.— Grouped data of frequency distributions for CAUSAPSCAL, EAST sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

ALTITUDE

	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800 FEET
①	8	19	10	11	12	32	52	10	2	N=156	– Frequency.					
	5.13	12.18	6.41	7.05	7.69	20.51	33.33	6.41	1.28		– %.					
	5.13	17.31	23.72	30.77	38.46	58.97	92.30	98.71	99.99		– Cumulative %.					
②		3	10	5	21	25	83	113	52	15	1	N=328				
		0.91	3.05	1.52	6.40	7.62	25.30	34.45	15.85	4.57	0.30					
		0.91	3.96	5.48	11.88	19.50	44.80	79.25	95.10	99.67	99.97					
③				1	2	7	10	38	33	47	40	43	27	7	1	N=256
				0.39	0.78	2.73	3.90	14.84	12.89	18.36	15.63	16.80	10.55	2.73	0.39	
				0.39	1.17	3.90	7.80	22.64	35.53	53.89	69.52	86.32	96.87	99.60	99.99	
④						2	11	42	176	122	54	12	6	N=425		
						0.47	2.59	9.88	41.41	28.71	12.71	2.82	1.41			
						0.47	3.06	12.94	54.35	83.06	95.77	98.59	100.00			

class intervals: 0-99 ft, 100-199 ft, etc.

Table A-8 - Grouped data of frequency distributions for CUCQ map sheet; tabulations of frequency, % frequency, and cumulative % frequency for altitude classes.

APPENDIX - B.

HISTOGRAMS of Frequency distributions.

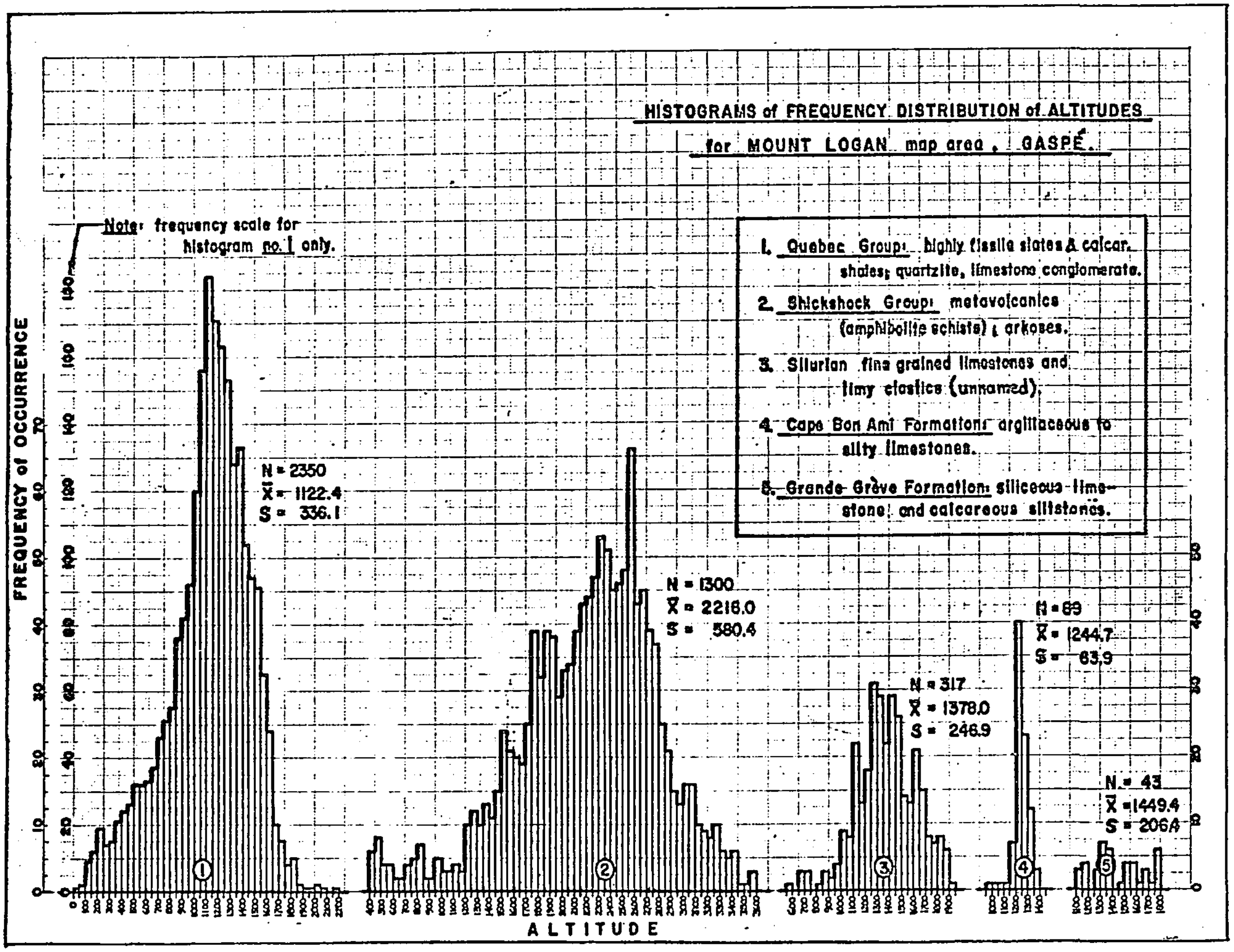


Figure B-1 - Histograms of frequency distribution of altitudes for Mount Logan map area, Gaspé.

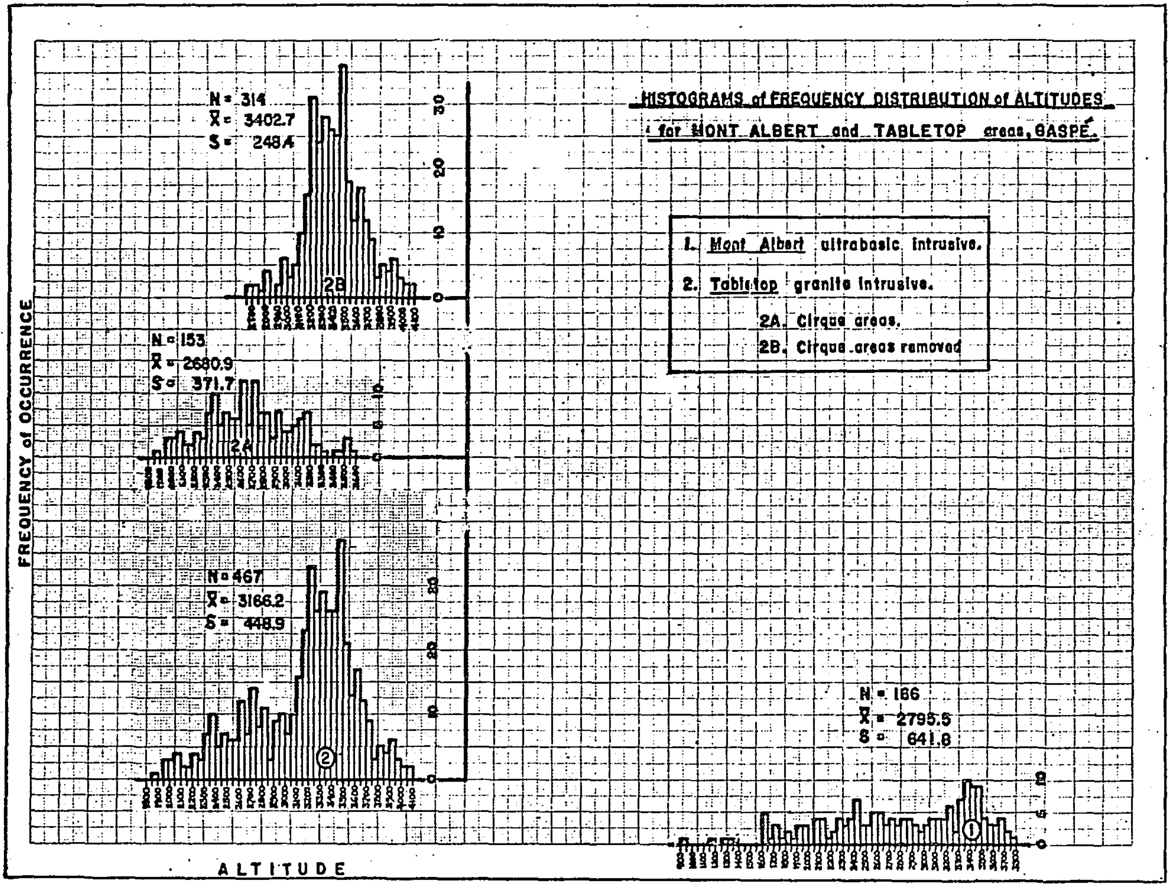


Figure B-2 - Histograms of frquency distribution of altitudes for MONT ALBERT and TABLETOP areas, Gaspé.

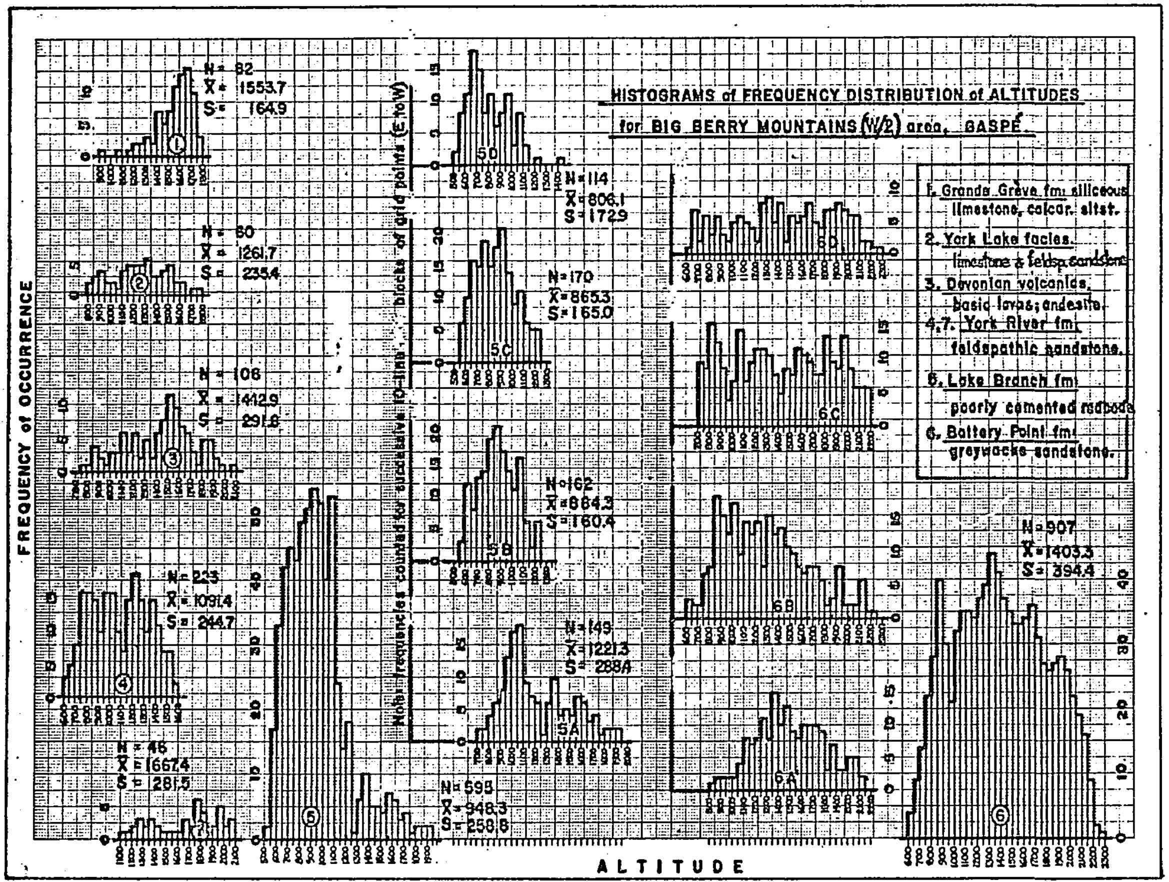


Figure B-3 - Histograms of frequency distribution of altitudes for BIG BERRY MOUNTAINS WEST map area, Gaspé.

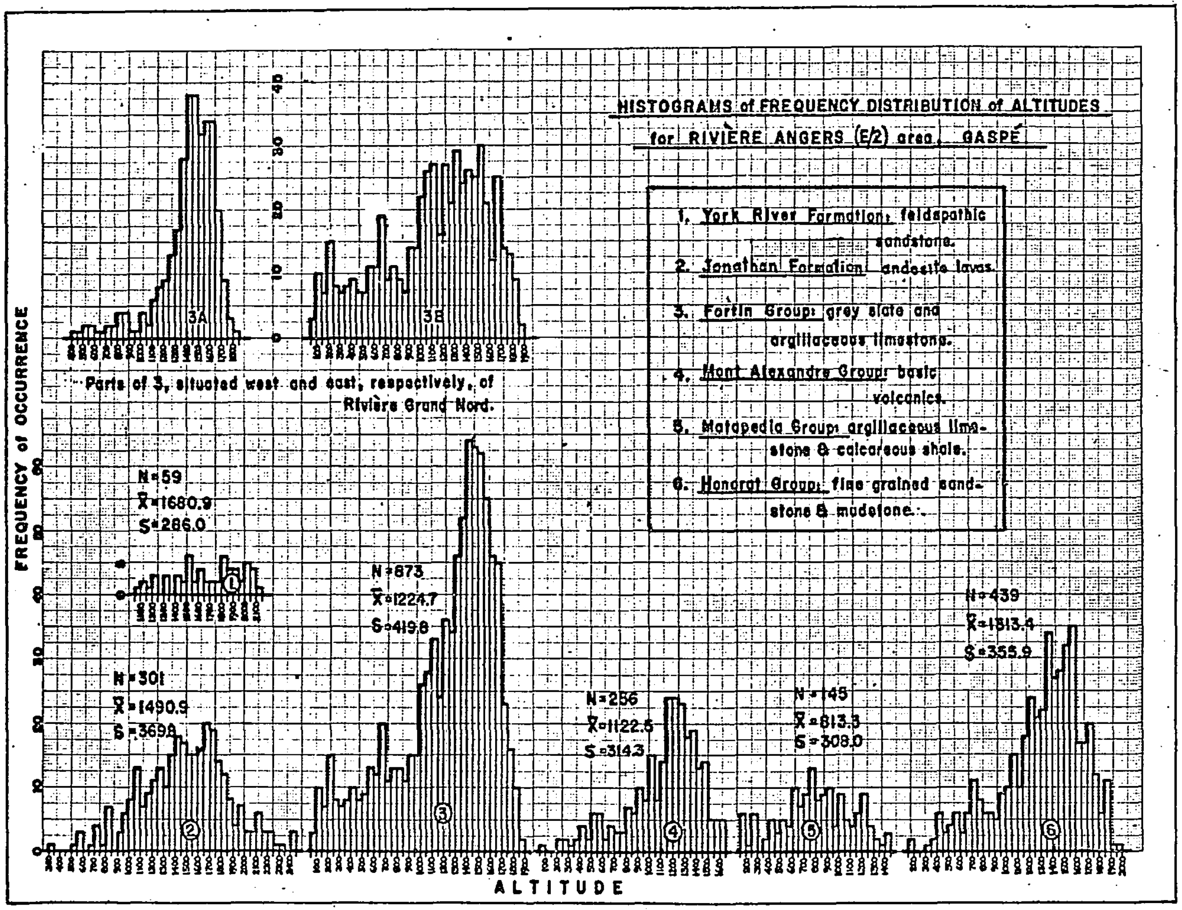


Figure B-4 - Histograms of frequency distribution of altitudes for RIVIERE ANGERS EAST map area, Gaspé.

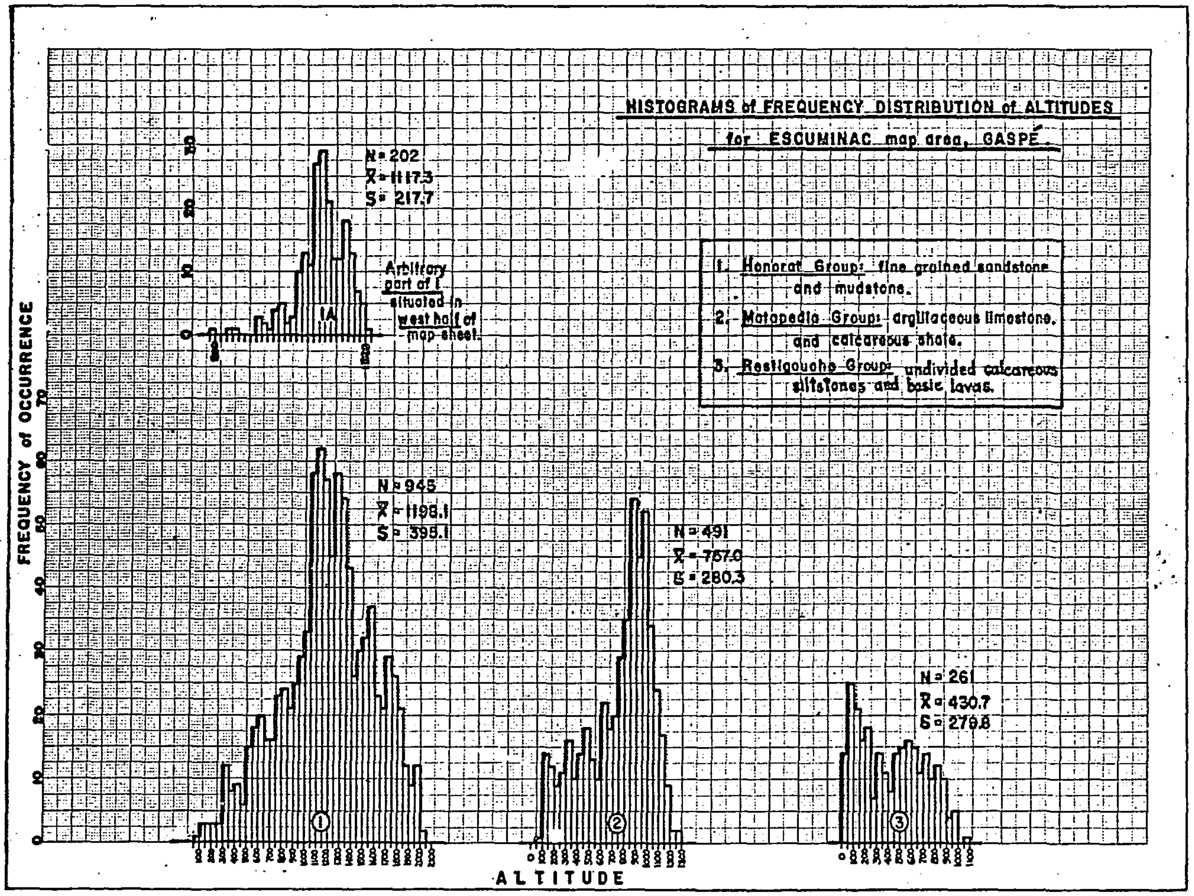


Figure B-5 - Histograms of frequency distribution of altitudes for ESCUMINAC map area, Gaspé.

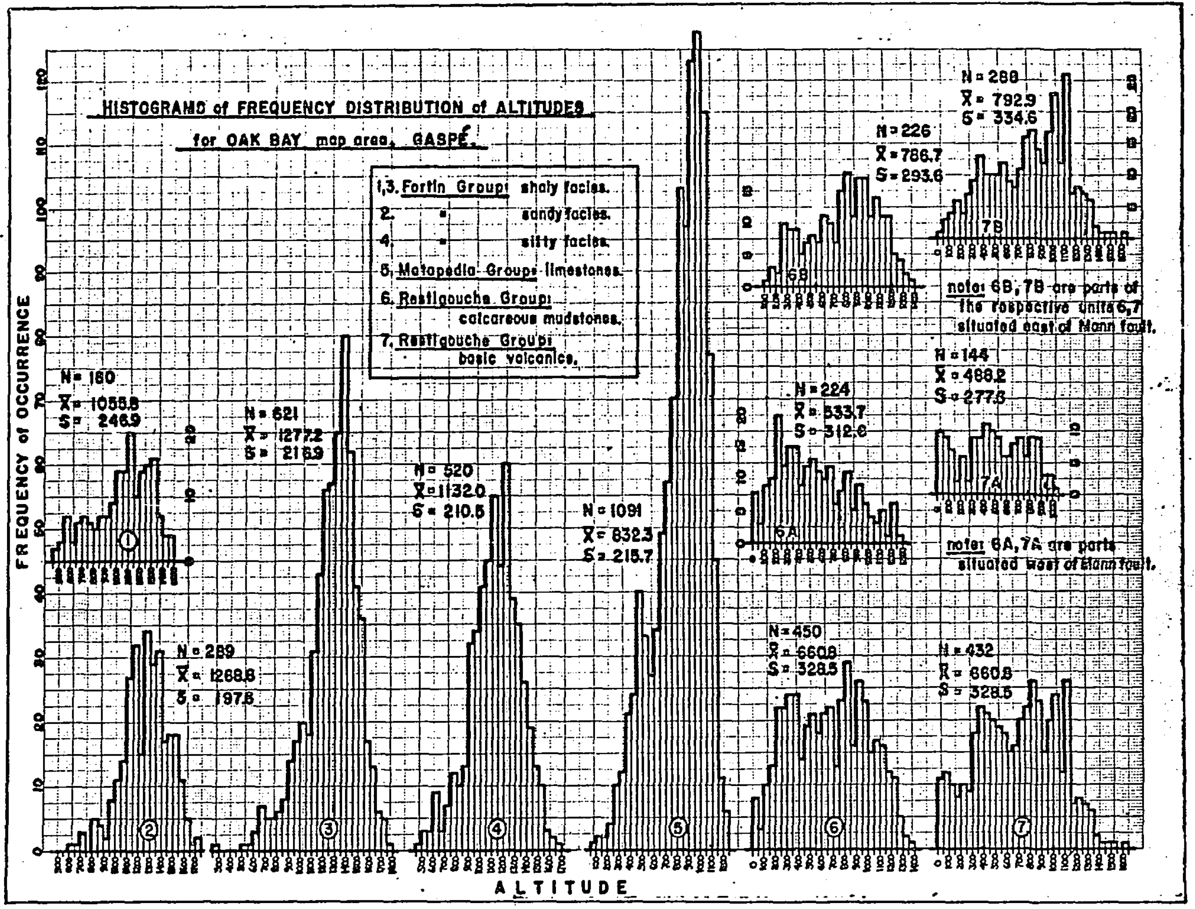


Figure B-6 - Histograms of frequency distribution of altitudes for OAK BAY map area, Gaspé.

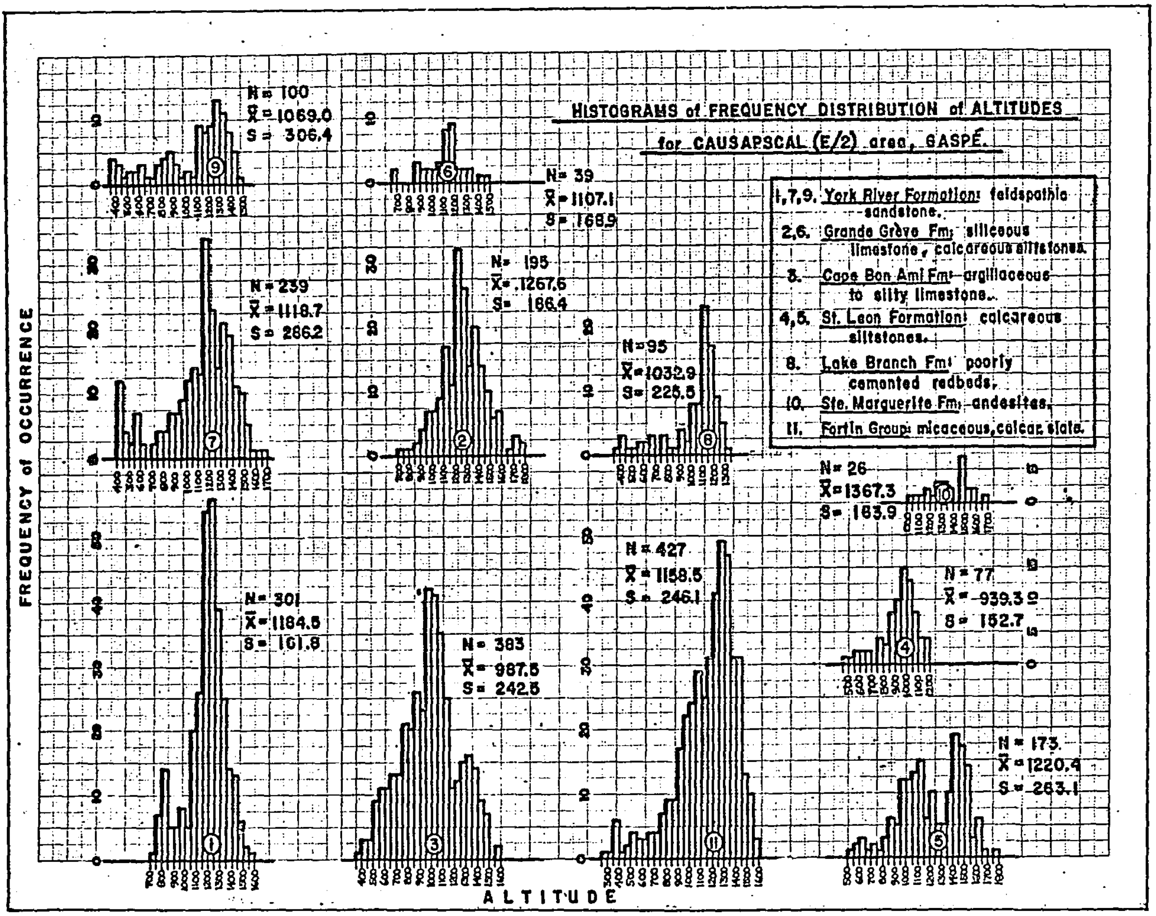


Figure B-7 - Histograms of frequency distribution of altitudes for CAUSAPSCAL EAST map area, Gaspé.

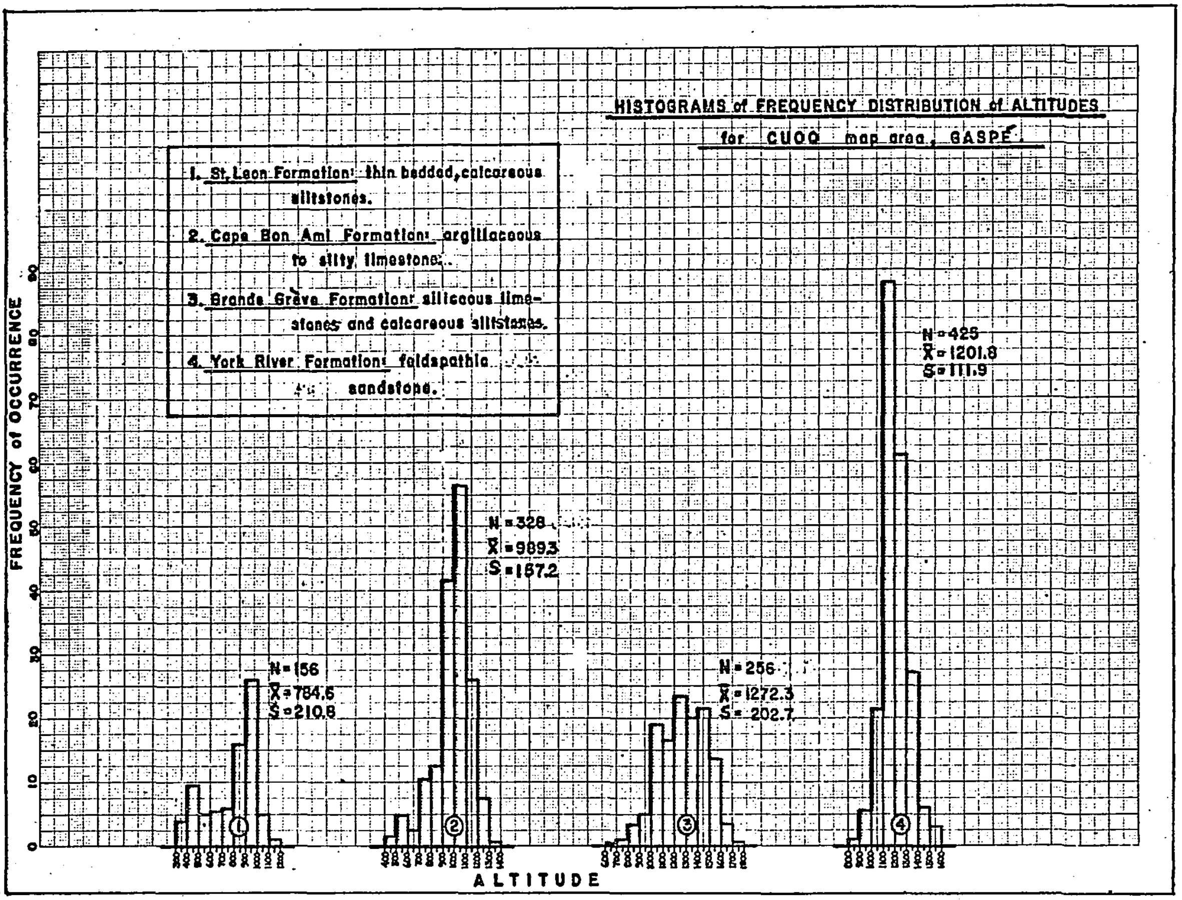


Figure B-8 - Histograms of frequency distribution of altitudes for CUOQ map area, Gaspé.

APPENDIX - C.

CUMULATIVE %-FREQUENCY CURVES of Frequency distributions.

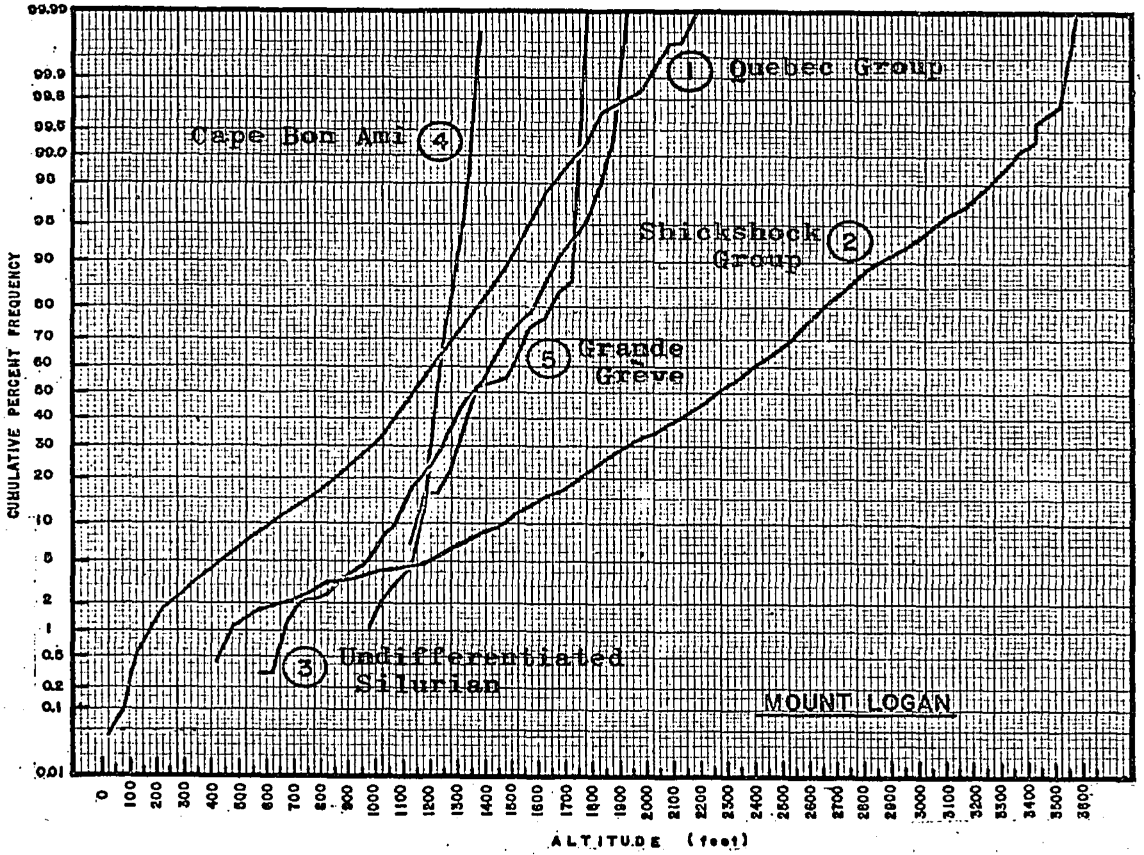


Figure C-I.— Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for MOUNT LOGAN sheet. Numbers refer to lithologic units and correspond to numbering on map sheet and histogram plots.

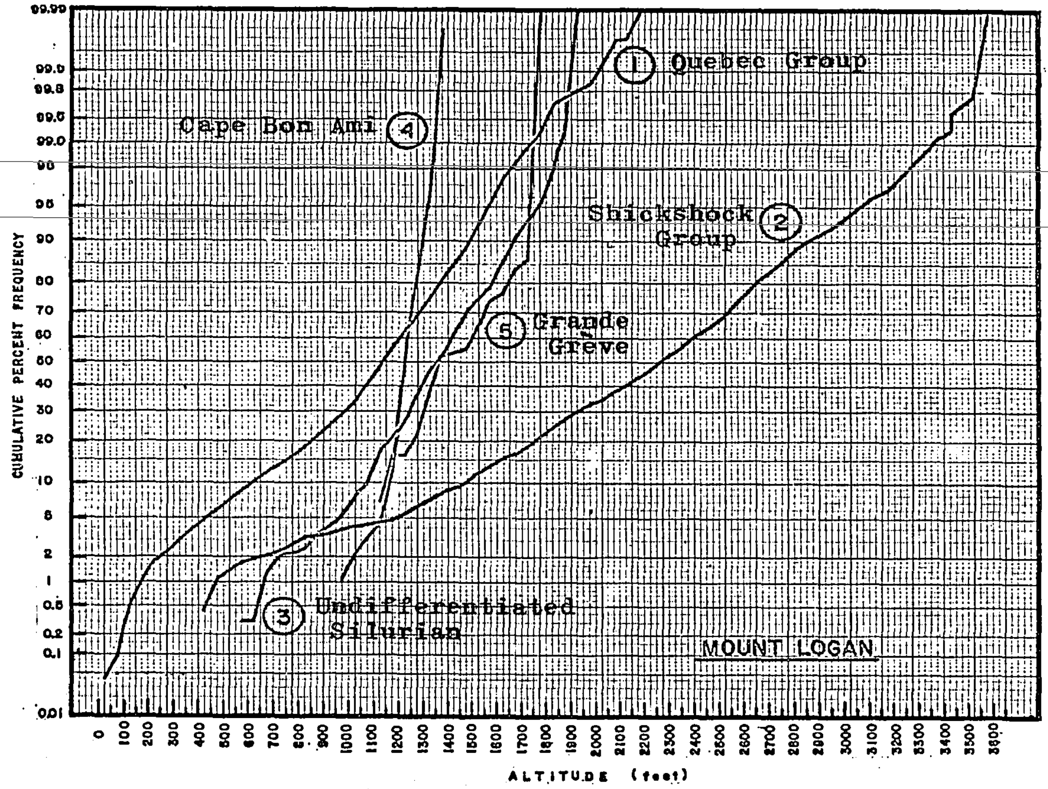


Figure C-I.- Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for MOUNT LOGAN sheet. Numbers refer to lithologic units and correspond to numbering on map sheet and histogram plots.

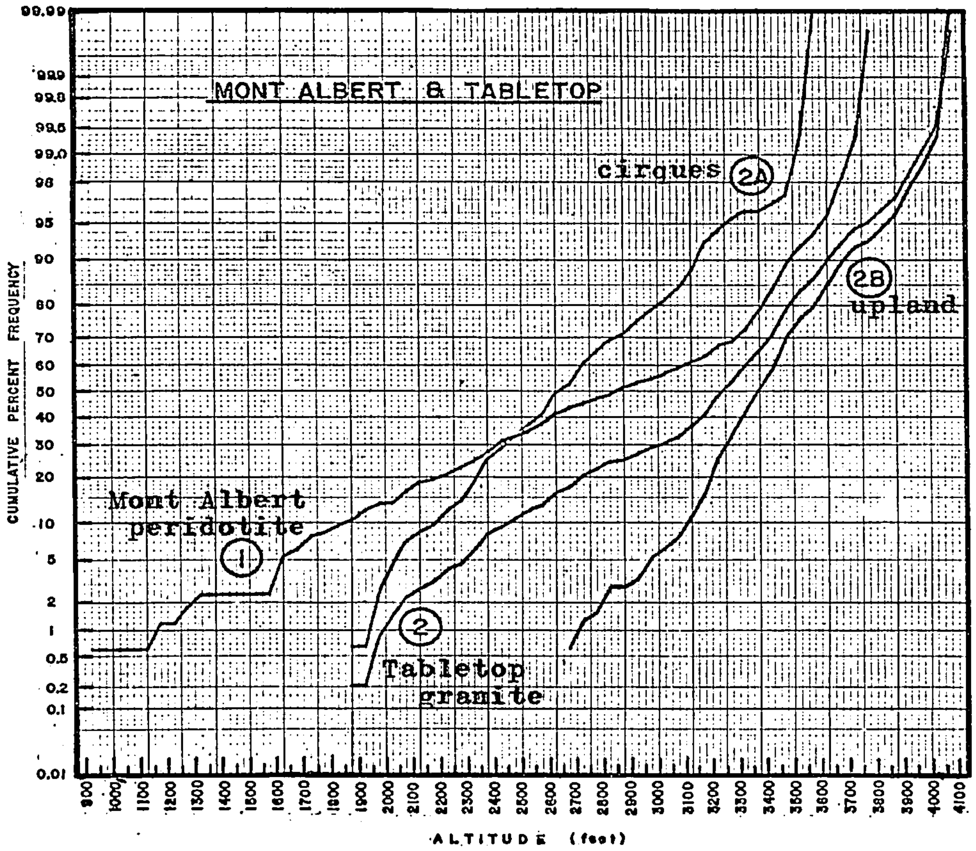


Figure C-2.— Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for MONT ALBERT & TABLETOP areas. Numbers refer to lithologic units and correspond to numbering on map sheet and histogram plots.

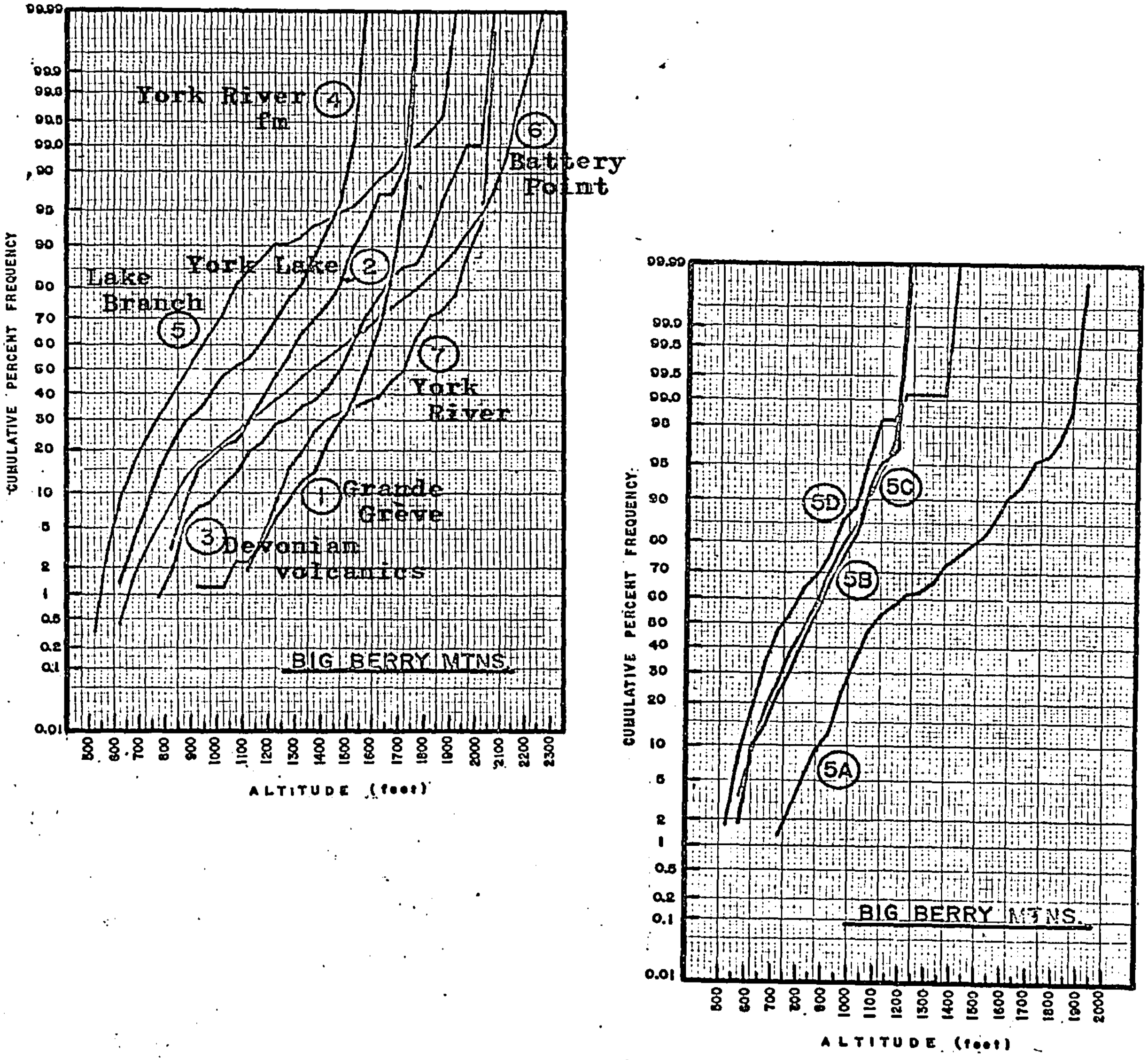


Figure C-3 .- Graphs of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for BIG BERRY MTNS. (West) sheet. Numbers refer to lithologic units and correspond to numbering on map sheet and histogram plots.

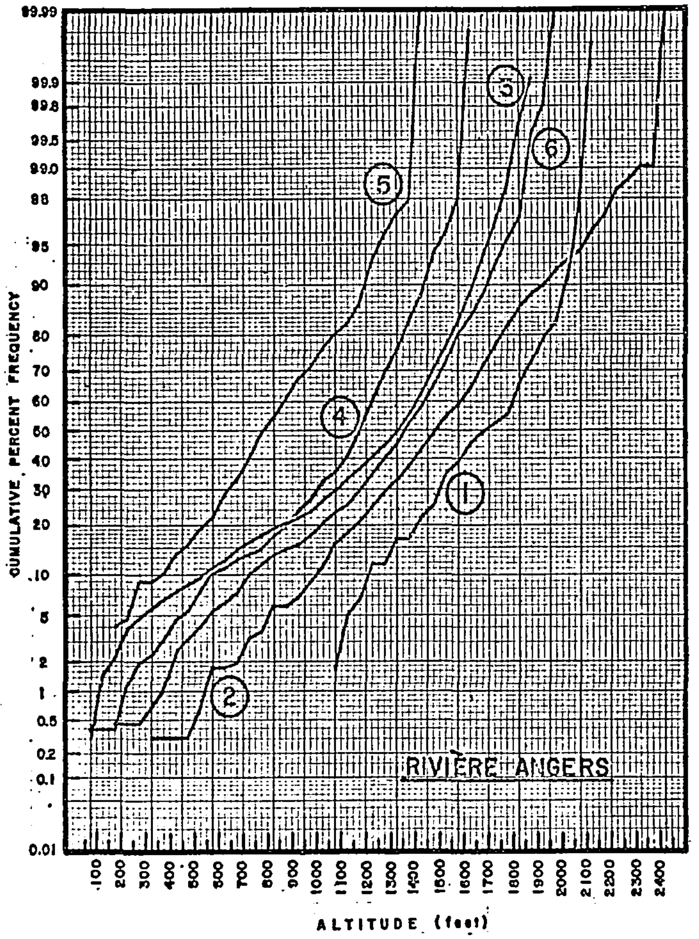


Figure C-4.- Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for RIVIERE ANGERS (East) sheet.

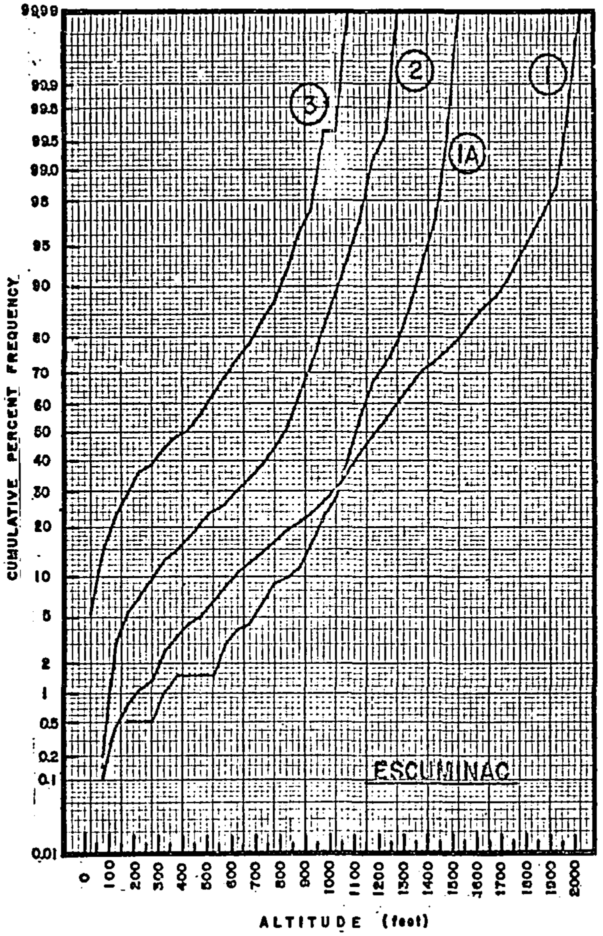


Figure C-5.- Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for ESCUMINAC sheet.

Note: numbers refer to lithologic units and correspond to numbering on map sheets and histogram plots.

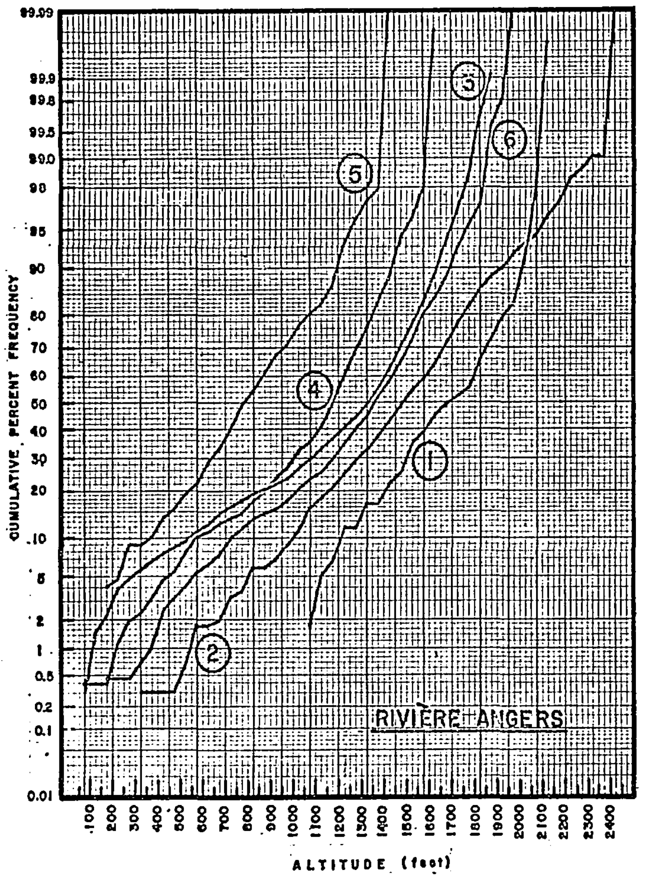


Figure C-4.- Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for RIVIERE ANGERS (East) sheet.

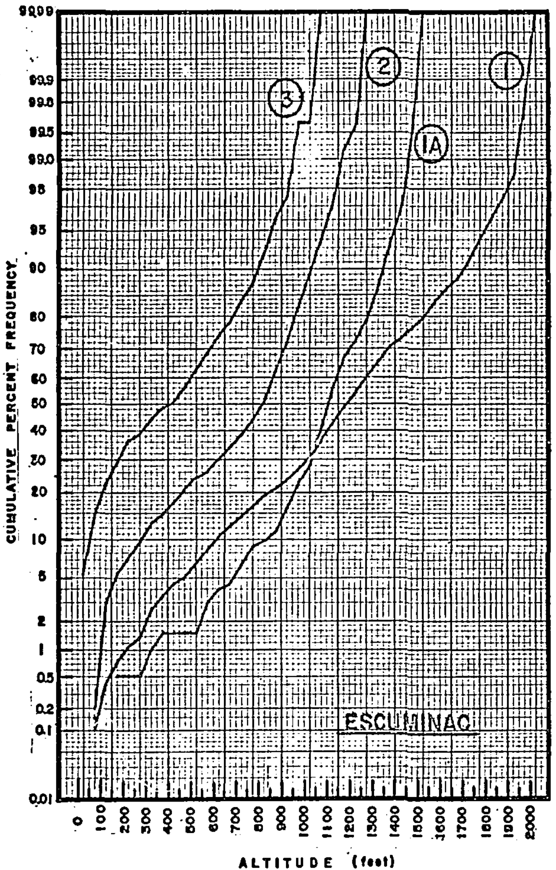


Figure C-5.- Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for ESCUMINAC sheet.

Note: numbers refer to lithologic units and correspond to numbering on map sheets and histogram plots.

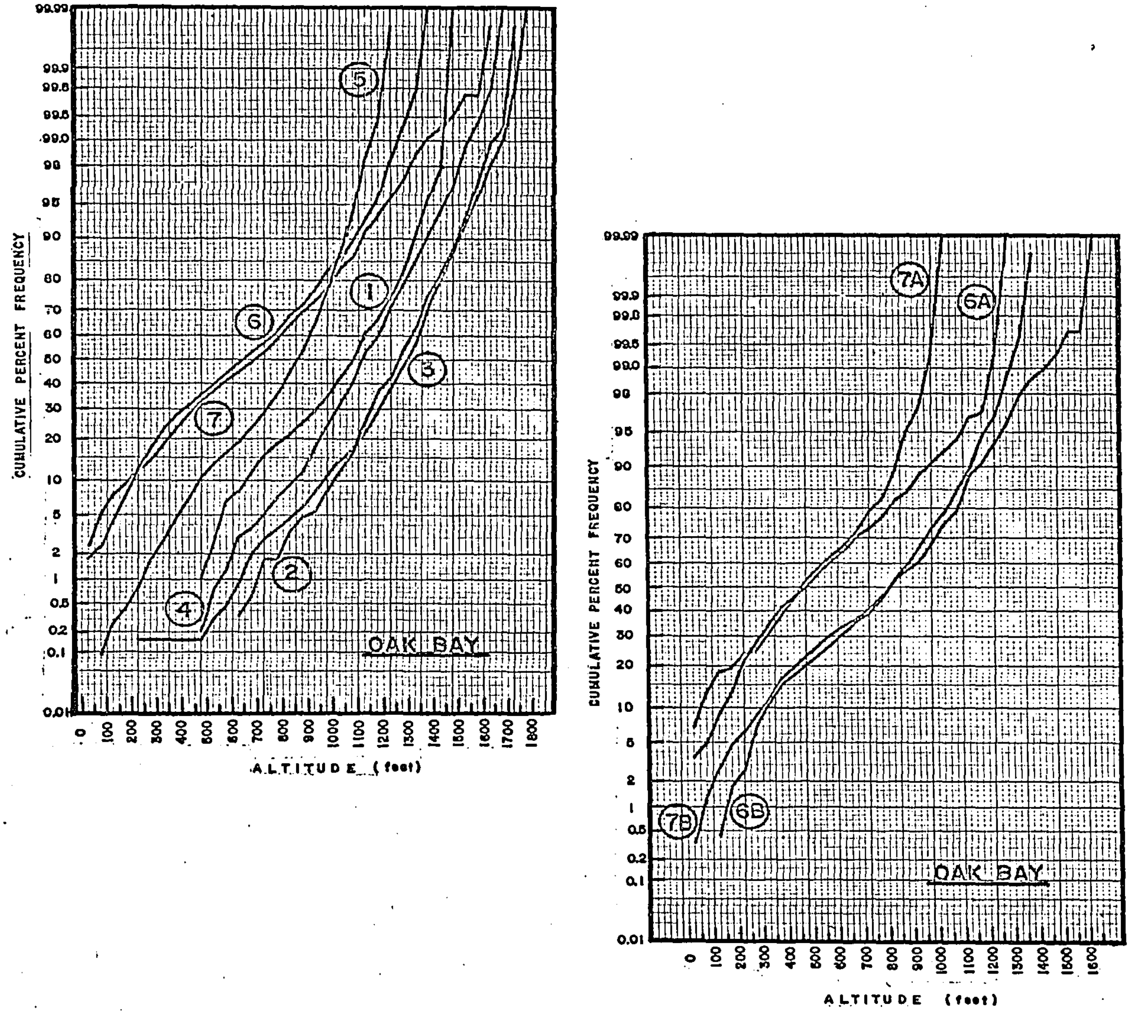


Figure C-6 .— Graphs of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for OAK BAY sheet. Numbers refer to lithologic units and correspond to numbering on map sheet and histogram plots.

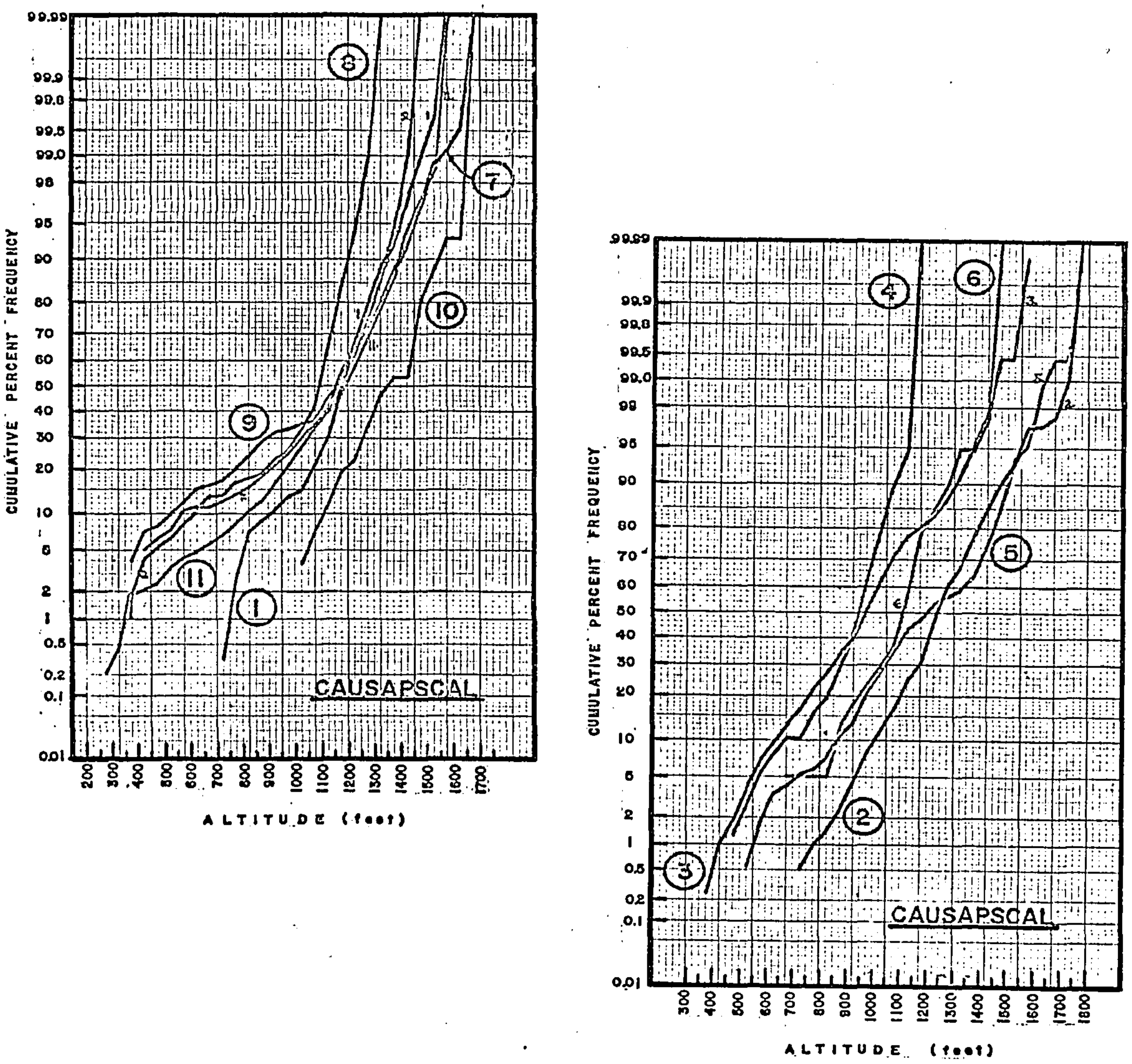


Figure C-7.- Graphs of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for CAUSAPSCAL (East) sheet. Numbers refer to lithologic units corresponding to numbering on map sheet and histogram plots.

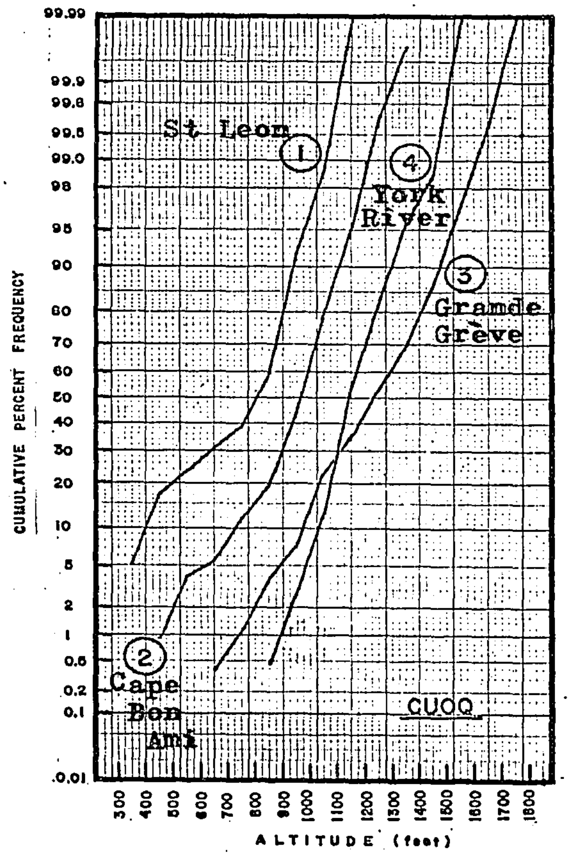


Figure C-8.- Graph of cumulative % frequency (probability ordinate) vs mid point of altitude classes, for CUOQ sheet. Numbers refer to lithologic units and correspond to numbering on map sheet and histogram plots.

APPENDIX - D.

TABULATED   Computed parameters of frequency distributions,

Moment measures and Curve-type criteria;

COMPUTER PROGRAM.

Frequency curve	Measures of central tendency				Dispersion		Skewness $(Sk)_m$	Kurtosis $(K)_m$
	Median (Md)	Arithmetic Mean $(\bar{X})$	Geometric Mean (GM)	Mode	Range Total Frequency (N)	Standard Deviation (σ)		
MAP (1) MOUNT LOGAN sheet								
1- Quebec gr	1160.5	1122.4	—		0 - 2200 (2350)	336.1	- 0.6480	3.4057
2- Shickshock gr	2289.4	2216.0	2116.0		400- 3600 (1300)	580.4	- 0.5879	3.5065
3- Silurian ls	1376.2	1378.0	—		550- 1950 (317)	246.9	- 0.2751	3.2160
4- Cape Bon Ami fm	1241.9	1244.7	1242.9		950- 1400 (89)	63.9	- 1.1198	6.8898
5- Grande Grève fm	1387.5	1449.4	—		1100-1800 (43)	206.4	0.1602	1.8399
MAP (2) MONT ALBERT & TABLETOP								
1- Mont Albert ultrabasics	2862.5	2795.5	—		900- 3800 (166)	641.8	- 0.5129	2.4660
2- Tabletop granite	3264.4	3166.2	—		1850-4100 (467)	448.9	- 0.6839	2.9159
2A- Tabletop (cirque areas)	2665.0	2680.9	—		1850-3600 (153)	371.7	0.1601	2.5433
2B- Tabletop (2 minus 2A)	3394.2	3402.7	—		2650-4100 (314)	248.4	0.0458	3.5643
MAP (3) BIG BERRY MTNS., (West) sheet								
1- Grande Grève fm	1595.5	1553.7	—		900-1800 (82)	164.9	- 1.3018	4.8832
2- York Lake fac	1260.0	1261.7	—		800-1800 (60)	235.4	- 0.0577	2.2725
3- Devonian volcs	1500.0	1442.9	—		750-2100 (106)	291.8	- 0.2983	2.4469

						(314)			
MAP (3)	BIG BERRY MTNS., (West) sheet								
	1- Grande Grève fm	1595.5	1553.7	—		900-1800 (82)	164.9	- 1.3018	4.8832
	2- York Lake fac	1260.0	1261.7	—		800-1800 (60)	235.4	- 0.0577	2.2725
	3- Devonian volcs	1500.0	1442.9	—		750-2100 (106)	291.8	- 0.2983	2.4469
	4- York River fm	1082.5	1091.4	1063.1		600-1600 (223)	244.7	0.0374	1.8981
	5- Lake Branch fm	914.4	948.3	916.8		500-1950 (595)	258.8	1.1745	4.6700
	5A- part of 5, see histograms	1125.0	1221.3	1188.9		700-1950 (149)	288.4	0.5916	2.3915
	5B- do	878.6	884.3	869.5		550-1250 (162)	160.4	0.1162	2.3279
	5C- do	861.1	865.3	849.6		550-1250 (170)	165.0	0.2558	2.3070
	5D- do	768.8	806.1	—		500-1450 (114)	172.9	0.6887	3.1525
	6- Battery Point fm	1385.0	1403.3	1345.0		600-2300 (907)	394.4	0.0803	2.0361
	7- York River fm	1750.0	1667.4	1642.3		1100-2100 (46)	281.5	- 0.3130	1.8195
MAP (4)	RIVIÈRE ANGERS (East) sheet								
	1- York River fm	1712.5	1680.9	—		1050-2150 (59)	286.0	-0 .3730	2.1093
	2- Jonathan fm	1508.3	1490.9	—		300-2450 (301)	369.8	- 0.1787	3.0825
	3- Fortin gr	1351.4	1224.7	1103.2		50-1900 (873)	419.8	- 0.9693	3.1120
	4- Mont Alexandre gr	1195.8	1122.5	—		50-1650 (256)	314.3	- 0.9641	3.5087
	5- Matapedia gr	809.4	813.3	—		150-1450 (145)	308.0	- 0.1831	2.4469
	6- Honorat gr	1381.6	1313.4	—		150-2000 (439)	355.9	- 0.8143	3.2191
MAP (5)	ESCUMINAC sheet								

	3- Fortin gr	1351.4	1224.7	1103.2		50-1900 (873)	419.8	-0.9693	3.1120
	4- Mont Alexandre gr	1195.8	1122.5	—		50-1650' (256)	314.3	-0.9641	3.5087
	5- Matapedia gr	809.4	813.3	—		150-1450 (145)	308.0	-0.1831	2.4469
	6- Honorat gr	1381.6	1313.4	—		150-2000 (439)	355.9	-0.8143	3.2191
MAP (5)	ESCUMINAC sheet								
	1- Honorat gr	1207.2	1198.1	1112.6		50-2050 (945)	395.1	-0.2921	2.7277
	2- Matapedia gr	840.7	757.0	678.5		50-1300 (491)	280.3	-0.7011	2.5274
	3- Restigouche gr	428.2	430.7	—		0-1100 (261)	279.8	0.1986	1.8224
MAP (6)	OAK BAY sheet								
	1- Fortin gr, shaly facies	1100.0	1055.8	1022.5		450-1500 (180)	246.9	-0.5222	2.4171
	2- Fortin gr, sandy facies	1281.6	1268.6	—		600-1750 (289)	197.6	-0.4127	3.2302
	3- Fortin gr, shaly facies	1313.5	1277.2	—		250-1800 (621)	216.9	-0.8375	4.1815
	4- Fortin gr, silty facies	1142.7	1132.0	1110.3		450-1700 (520)	210.5	-0.3867	3.1993
	5- Matapedia gr	879.1	832.3	795.2		50-1250 (1091)	215.7	-0.8230	3.1160
	6- Restigouche gr, mudstones	663.6	660.8	547.3		0-1400 (450)	328.5	0.0098	1.9573
	7- Restigouche gr, basic volcs	715.0	691.3	—		0-1650 (432)	347.8	-0.0404	2.1990
	6A-part of 6, west of Mann fault	495.8	533.7	417.0		0-1300 (224)	312.6	0.4288	2.3042
	6B-part of 6, east of Mann fault	825.0	786.7	716.6		100-1400 (226)	293.6	-0.3118	2.1632
	7A-part of 7, west of Mann fault	485.0	488.2	357.1		0-1050 (144)	277.6	-0.0847	1.9463
	7B-part of 7, east of Mann fault	832.4	792.9	—		0-1650 (288)	334.6	-0.2441	2.2365
MAP									

	of Mann fault					(144)			
	7B-part of 7, east of Mann fault	832.4	792.9	—		0-1650 (288)	334.6	- 0.2441	2.2365
MAP (7)	CAUSAPSCAL sheet								
	1- York River fm	1204.9	1184.5	1172.3		700-1600 (301)	161.8	- 0.7242	3.5520
	2- Grande Grève fm	1260.6	1267.6	—		700-1800 (195)	186.4	0.0361	3.3656
	3- Cape Bon Ami fm	994.6	987.5	—		350-1600 (383)	242.5	- 0.0435	2.6173
	4- St. Leon fm.	968.3	939.3	—		450-1200 (77)	152.7	- 1.0382	3.9349
	5- St. Leon fm.	1222.5	1220.4	—		500-1800 (173)	263.1	- 0.3823	2.4724
	6- Grande Grève fm	1134.4	1107.1	—		650-1500 (39)	168.9	- 0.5236	3.6721
	7- York River fm	1180.1	1118.7	—		400-1700 (239)	286.2	- 0.9539	3.3377
	8- Lake Branch fm	1084.4	1032.9	—		350-1350 (95)	225.5	- 1.4421	4.1289
	9- York River fm	1181.3	1069.0	1010.5		350-1500 (100)	306.4	- 0.9010	2.6300
	10- Ste Marguerite volcs	1375.0	1367.3	—		1000-1700 (26)	163.9	- 0.3090	2.2764
	11- Fortin gr, shaly facies	1214.0	1158.5	1123.8		250-1600 (427)	246.1	- 1.1104	4.3116
MAP (8)	CUCQ sheet								
	1- St. Leon fm	856.3	784.6	750.2		300-1200 (156)	210.8	- 0.6818	2.2144
	2- Cape Bon Ami fm	1015.1	989.3	974.5		400-1400 (328)	157.2	- 1.0373	4.4640
	3- Grande Grève fm	1278.7	1272.3	1255.1		600-1800 (256)	202.7	- 0.2534	2.6098
	4- York River fm	1189.5	1201.8	1196.6		800-1600 (425)	111.9	0.3236	3.8860

Table D-1.- Values of frequency distribution parameters (computed from formulae given in text).

	Frequency curve	Moments of distribution about the arithmetic mean				Determination of curve type from Pearson's System of Frequency Curves			
		1-st	2-nd	3-rd	4-th	Curve type criteria			Curve Type
		m_1	m_2	m_3	m_4	β_1	β_2	κ	
MAP (1)	MOUNT LOGAN sheet		(VARIANCE)						
	1- Quebec gr.	0	112958.9792	- 24600061.95	4345625.8	0.4199	3.4057	- 0.7774	I
	2- Shickshock gr	0	336847.0976	- 114926490.0	39786957.0	0.3456	3.5065	-11.8789	I
	3- Silurian ls	0	60976.8176	- 4141692.98	1195750.0	0.0757	3.2160	0.2822	IV
	4- Cape Bon Ami fm	0	4079.6615	- 291795.75	11467.108	1.2540	6.8898	0.3207	IV
	5- Grande Grève fm	0	42601.4044	1408245.43	333918.96	0.0256	1.8399	- 0.0086	I
MAP (2)	MONT ALBERT & TABLETOP								
	1- Mont Albert, ultrabasics	0	411869.5776	- 135569170.0	41832082.0	0.2631	2.4660	- 0.1166	I
	2- Tabletop, granite	0	201528.8896	- 61872842.0	11842520.0	0.4677	2.9159	- 0.2538	I
	2A- Tabletop, (cirque areas)	0	138168.0000	8223318.02	4855175.8	0.0256	2.5433	- 0.0197	I
	2B- Tabletop, (2 minus 2A)	0	61700.4696	702036.63	1356897.6	0.0021	3.5643	0.0014	I, (VII)
MAP (3)	BIG BERRY MTNS., (West) sheet								
	1- Grande Grève fm	0	27196.9796	- 5838947.02	361200.73	1.6948	4.8832	- 1.3829	I
	2- York Lake fac	0	55405.5512	- 752238.13	697595.73	0.0033	2.2725	- 0.0017	I, (II)
	3- Devonian volcs	0	85150.4008	- 7412425.52	1774173.3	0.0890	2.4469	- 0.0505	I
	4- York River fm	0	59855.4128	548119.73	680042.49	0.0014	1.8981	- 0.0005	II
	5- Lake Branch fm	0	66958.1584	20349174.58	2093738.1	1.3794	4.6700	- 1.7478	I
	5A- part of 5, see histograms.	0	83191.0664	14195625.0	1655091.1	0.3500	2.3915	- 0.1317	I
	5B- do	0	25716.7340	479297.37	153953.68	0.0135	2.3279	- 0.0075	I

	2- York Lake fac	0	55405.5512	- 752238.13	697595.73	0.0033	2.2725	- 0.0017	I, (II)
	3- Devonian volcs	0	85150.4008	- 7412425.52	1774173.3	0.0890	2.4469	- 0.0505	I
	4- York River fm	0	59855.4128	548119.73	680042.49	0.0014	1.8981	- 0.0005	II
	5- Lake Branch fm	0	66958.1584	20349174.58	2093738.1	1.3794	4.6700	- 1.7478	I
	5A- part of 5, see histograms.	0	83191.0664	14195625.0	1655091.1	0.3500	2.3915	- 0.1317	I
	5B- do	0	25716.7340	479297.37	153953.68	0.0135	2.3279	- 0.0075	I
	5C- do	0	27214.6172	1148487.46	170864.56	0.0654	2.3070	- 0.0322	I
	5D- do	0	29885.5400	3558346.24	281566.02	0.4744	3.1525	- 0.3589	I
	6- Battery Point fm	0	155542.5552	4923783.68	4926052.9	0.0064	2.0361	- 0.0026	I, (II)
	7- York River fm	0	79235.5808	- 6981678.59	1142343.8	0.0980	1.8195	- 0.0307	I
MAP (4)	RIVIÈRE ANGERS (East) sheet								
	1- York River fm	0	81786.8384	- 8724800.10	1410914.3	0.1391	2.1093	- 0.0515	I
	2- Jonathan fm.	0	136788.8720	- 9042286.28	5767746.6	0.0319	3.0825	0.3491	IV
	3- Fortin gr	0	176199.7792	- 71691242.70	9661634.5	0.9395	3.1120	- 0.3512	I
	4- Mont Alexandre gr	0	98811.9040	- 29945063.42	3425803.6	0.9294	3.5087	- 0.4942	I
	5- Matapedia gr	0	94862.5376	- 5349771.21	2201939.2	0.0335	2.4469	- 0.0213	I
	6- Honorat gr	0	126641.7888	- 36699740.16	5162791.3	0.6631	3.2191	- 0.3797	I
MAP (5)	ESCUMINAC sheet								
	1- Honorat gr	0	156118.8032	- 18020249.80	6648195.7	0.0853	2.7277	- 0.0820	I
	2- Matapedia gr	0	78580.4072	- 15442847.33	1560624.7	0.4915	2.5274	- 0.1797	I
	3- Restigouche gr	0	78261.9832	4348742.71	1116186.4	0.0395	1.8224	- 0.0129	I
MAP (6)	OAK BAY sheet								
	1- Fortin gr	0	60979.8576	- 7863697.92	898802.19	0.2727	2.4171	- 0.1139	I

MAP (5)	ESCUMINAC sheet								
	1- Honorat gr	0	156118.8032	- 18020249.80	6648195.7	0.0853	2.7277	- 0.0820	I
	2- Matapedia gr	0	78580.4072	- 15442847.33	1560624.7	0.4915	2.5274	- 0.1797	I
	3- Restigouche gr	0	78261.9832	4348742.71	1116186.4	0.0395	1.8224	- 0.0129	I
MAP (6)	OAK BAY sheet								
	1- Fortin gr shaly facies	0	60979.8576	- 7863697.92	898802.19	0.2727	2.4171	- 0.1139	I
	2- Fortin gr sandy facies	0	39050.7140	- 3184488.40	492596.23	0.1703	3.2302	- 2.6410	I
	3- Fortin gr shaly facies	0	47027.0556	- 8540877.93	924765.82	0.7014	4.1815	2.3889	VI
	4- Fortin gr silty facies	0	44301.6876	- 3605591.71	627906.00	0.1495	3.1993	- 2.3282	I
	5- Matapedia gr	0	46539.4736	- 8263071.95	674905.28	0.6774	3.1160	- 0.3373	I
	6- Restigouche gr, mudstones	0	107931.0496	349051.21	2280115.9	0.0001	1.9573	- 0.0000	VII
	7- Restigouche gr, basic volcs	0	120966.3008	- 1700089.40	3217815.4	0.0016	2.1990	- 0.0008	I,(VII)
	6A-part of 6, west of Mann fault	0	97725.5488	13098362.47	2200623.4	0.1838	2.3042	- 0.0768	I
	6B-part of 6, east of Mann fault	0	86178.8720	- 7888764.52	1606556.6	0.0972	2.1632	- 0.0394	I
	7A-part of 7, west of Mann fault	0	77048.1216	- 1810797.70	1155394.6	0.0072	1.9463	- 0.0027	I,(VII)
	7B-part of 7, east of Mann fault	0	111980.5696	- 9145383.22	2804495.1	0.0596	2.2365	- 0.0273	I
MAP (7)	CAUSAPSCAL (East) sheet								
	1- York River fm	0	26181.1110	- 3068035.51	243472.71	0.5245	3.5520	- 0.9489	I
	2- Grande Grève fm	0	34752.3976	233990.60	406475.40	0.0013	3.3656	0.0014	IV,(VII)
	3- Cape Bon Ami fm	0	58811.5976	- 621123.23	905280.91	0.0019	2.6173	- 0.0019	I,(II)
	4- St. Leon fm	0	23302.4108	- 3693148.16	213668.24	1.0779	3.9349	- 0.7598	I
	5- St. Leon fm	0	69198.2624	- 6958997.61	1183862.7	1.1462	2.4724	- 0.0775	I
	6- Grande Grève fm	0	28523.9960	- 2522411.26	298770.29	0.2742	3.6721	0.4217	IV

	7A-part of 7, west of Mann fault	0	77048.1216	- 1810797.70	1155394.6	0.0072	1.9463	- 0.0027	I,(VII)
	7B-part of 7, east of Mann fault	0	111980.5696	- 9145383.22	2804495.1	0.0596	2.2365	- 0.0273	I
MAP (7)	CAUSAPSCAL (East) sheet								
	1- York River fm	0	26181.1110	- 3068035.51	243472.71	0.5245	3.5520	- 0.9489	I
	2- Grande Grève fm	0	34752.3976	233990.60	406475.40	0.0013	3.3656	0.0014	IV,(VII)
	3- Cape Bon Ami fm	0	58811.5976	- 621123.23	905280.91	0.0019	2.6173	- 0.0019	I,(II)
	4- St. Leon fm	0	23302.4108	- 3693148.16	213668.24	1.0779	3.9349	- 0.7598	I
	5- St. Leon fm	0	69198.2624	- 6958997.61	1183862.7	1.1462	2.4724	- 0.0775	I
	6- Grande Grève fm	0	28523.9960	- 2522411.26	298770.29	0.2742	3.6721	0.4217	IV
	7- York River fm	0	81885.2864	- 22351280.13	1238008.7	0.9099	3.3377	- 0.4188	I
	8- Lake Branch fm	0	50858.7216	- 16540564.48	1067982.2	2.0797	4.1289	- 0.6458	I
	9- York River fm	0	93864.0000	- 25910230.84	2317112.7	0.8118	2.6300	- 0.2506	I
	10- Ste Marguerite volcs	0	26863.9040	- 1360376.45	164283.19	0.0955	2.2764	- 0.0435	I
	11- Fortin gp, shaly facies	0	60552.9240	- 16546269.39	1580920.1	1.2331	4.3116	- 1.1305	I
MAP (8)	CUCQ sheet								
	1- St. Leon fm	0	44442.7992	- 6387458.97	437372.30	0.4648	2.2144	- 0.1427	I
	2- Cape Bon Ami fm	0	24703.2076	- 4027339.98	272416.85	1.0759	4.4640	- 3.4184	I
	3- Grande Grève fm	0	41105.8032	- 2112246.27	440974.54	0.0642	2.6098	- 0.0507	I
	4- York River fm	0	12520.4147	453416.28	60916.84	0.1047	3.8860	0.0559	IV

* after: Elderton, 1938: "Frequency Curves and correlation".

Table D-2.- Values of moments calculated about the arithmetic mean of frequency distributions; and parameters used in Pearson curve correlation.

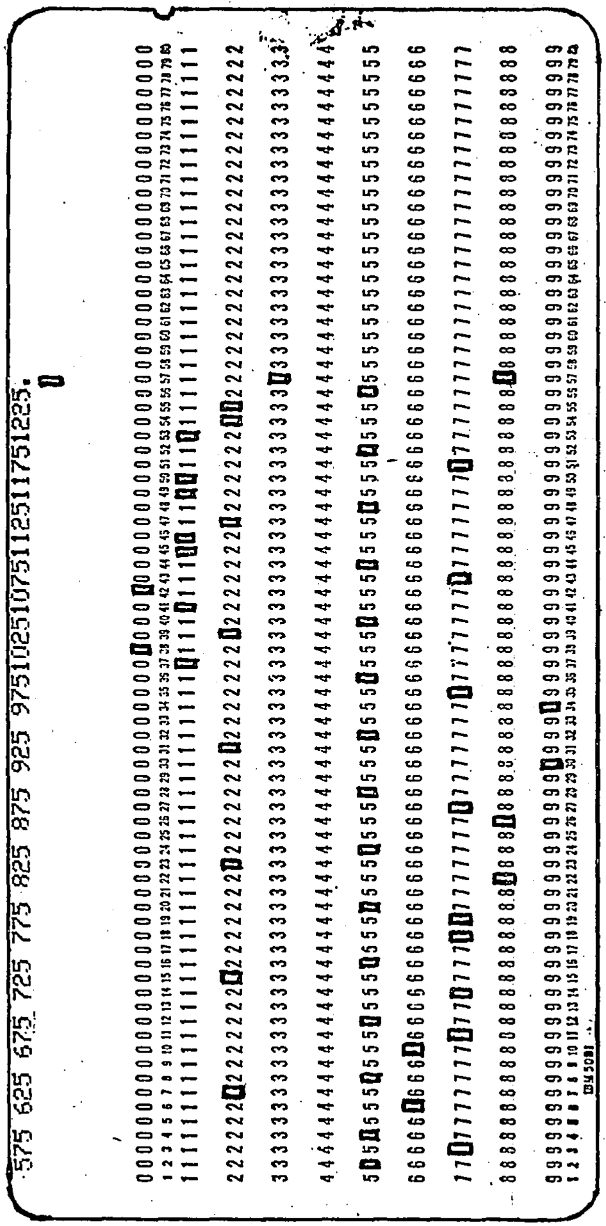
As given in text, $\beta_1 = \frac{(m_3)^2}{(m_2)^3}$; $\beta_2 = \frac{(m_4)}{(m_2)^2}$; $\kappa = \frac{\beta_1(\beta_2 - 3)^2}{4(4\beta_2 - 3\beta_1)(2\beta_2 - 3\beta_1 - 6)}$

FORTRAN SOURCE LIST.

```
ISN        SOURCE STATEMENT
  0 $IBFTC MAIN
  1          DIMENSION XMX(60),SDS(60),SIG(56,56), NN(60),TT(56,56),VAR(56,56),
           1 CL(70),CNL(70),SVAR(56,56)
  2          DO 17 K=1,56
  3          PRINT 40,K
  4      40  FORMAT(8HKSET NO.,I4)
  5          READ 1, ND ,N
 10       1  FORMAT(I2, I4)
 11          READ 2,  (CL(I),I=1,ND)
 16       2  FORMAT(20F4.0)
 17          READ 2,  (CNL(I), I=1,ND)
    C  CALCULATE MEAN
 24          SM=0
 25           GM=0.0
 26          DO 4 I=1,ND
 27           IF(CNL(I) .EQ.0.0) GO TO 4
 32          GM=GM+CNL(I)*ALOG10(CL(I))
 33       4  SM=CNL(I)*CL(I)+SM
 35           GM=10.0**(GM/FLOAT(N))
 36          XM=SM/FLOAT (N)
 37          PRINT 6,  XM ,GM
 40       6  FORMAT(7HKMEAN =,F12.4,  15H    GEOM.  MEAN =,F12.4)
    C  CALCULATE MOMENTS
 41          SM=0
 42          SA=0
 43          SB=0
 44          SP=0
 45          DO 14 I=1,ND
 46          SA=SA+CNL(I)*(CL(I)-XM)**2
 47          SB=SB+CNL(I)*(CL(I)-XM)**3
 50          SP=SP+CNL(I)*(CL(I)-XM)**4
 51      14  SM=CNL(I)*(CL (I)-XM)+SM
 53          XM2= SA/FLOAT (N)
 54          XM3=SB/ FLOAT(N)
 55          XM4= SP/FLOAT(N)
 56          XM1=SM/FLOAT (N)
 57          SD=SQRT(XM2)
 60          X3=XM3/SD**3
 61          X4=XM4/SD**4
 62           A=FLOAT(N)
 63            RSD=1.0/SD
 64            ASD=SD/SQRT (A)
 65             SD1=SQRT(2.0/A)*(SD**2)
```

```
      X4=XM4/SD**4
       A=FLOAT(N)
        RSD=1.0/SD
        ASD=SD/SQRT(A)
         SD1=SQRT(2.0/A)*(SD**2)
         SD2=SQRT(6.0/A)*(SD**3)
        SD3=SQRT(96.0/A)*(SD**4)
      PRINT 8. XM1,XM2,XM3,XM4.SD ,RSD,ASD ,SD1,SD2,SD3
    8 FORMAT(15HKFIRST MOMENT =,F12.4,2X,15HSECOND MOMENT =,F15.4,
     112X,14HTHIRD MOMENT =E17.8/2X,15HFOURTH MOMENT =,   E17.8/
     221HKSTANDARD DEVIATION =,F12.4, 9H   1/SD =,F12.4,15H   SD/SQRT(N)
     3 =,F12.4/9H   SDU2 =,E17.8,9H   SDU3 =E17.8,9H   SDU4 =,E17.8)
      PRINT 30,X3,X4
   30 FORMAT(1HK,49HVALUES FOR DIFFERENCES FROM NORMAL CURVE CRITERIA
     1/1HK,11H SKEWNESS =,F12.4,4X,10HKURTOSIS =,F13.4)
C     CALCULATE CURVE TYPE CRITERIA
      B1=XM3**2/XM2**3
      B2=XM4/XM2**2
      XK= B1*(B2+3.0 )**2/((14.0*14.0*B2-3.0*B1) *12.0*B2-3.0*B1
      X=X3*(B2+3.0)/12.0*15.0*B2-6.0*B1-9.0) )
      XMM=XM-X*50
      PRINT 20, B1,B2, XK   ,X,XMM
   20 FORMAT19 HKBETA 1 =, F12.4,2X,8HBETA 2 = F12.4,6HKAPA =,F12.4,
     1 2X,           .2X,16HSKEWNESS COEFF =,F12.4,2X,6HMODE =, F12.4)
      AN(K)=N
      SDS(K)=XM2
      XMX(K)=XM
   17 CONTINUE
      PRINT 19
      DO 18 I=1,56
      DO 18 J=1,56
      IF(I.EQ.J) GO TO 18
      VAR(I,J)=SDS(I)/AN(I)+SDS(J) /AN(J)
      SVAR(I,J)=SQRT(VAR(I,J))
      TT(I,J)=(XMX(I)-XMXIJ))/SVAR(I.J)
      PRINT119, I,J,VARIJ,J),SVAR(I,J),TT(J,J).
   18 CONTINUE
   19 FORMAT(1HK,2X,1HI,2X,1HJ,8X,8HVARIANCE,4X,14HSTANDARD ERROR.
     1 4X,6HT-TEST)
  119 FORMAT(1HJ.2I3,F18.4,F18.4,F18.4,F18.4)
      STOP
      END.
```

Table D-3 – Computer program for IBM 7044 data processing system; for the computation of parameters of frequency distributions.



```
575 625 675 725 775 825 875 925 97510251075112511751225.
```

Figure D-4a

Sample computer card: input of altitude data (middle of class intervals).

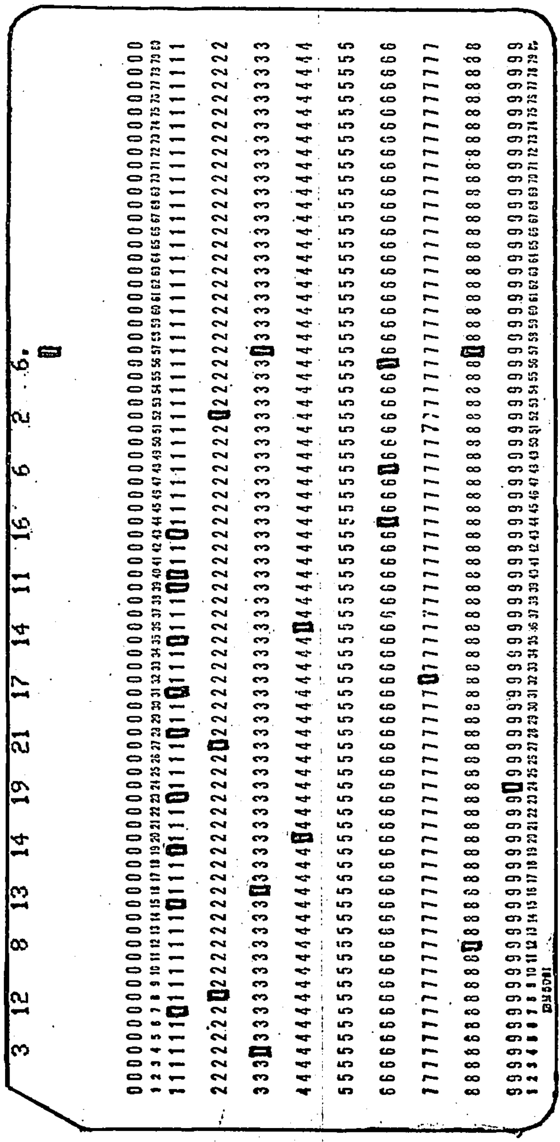
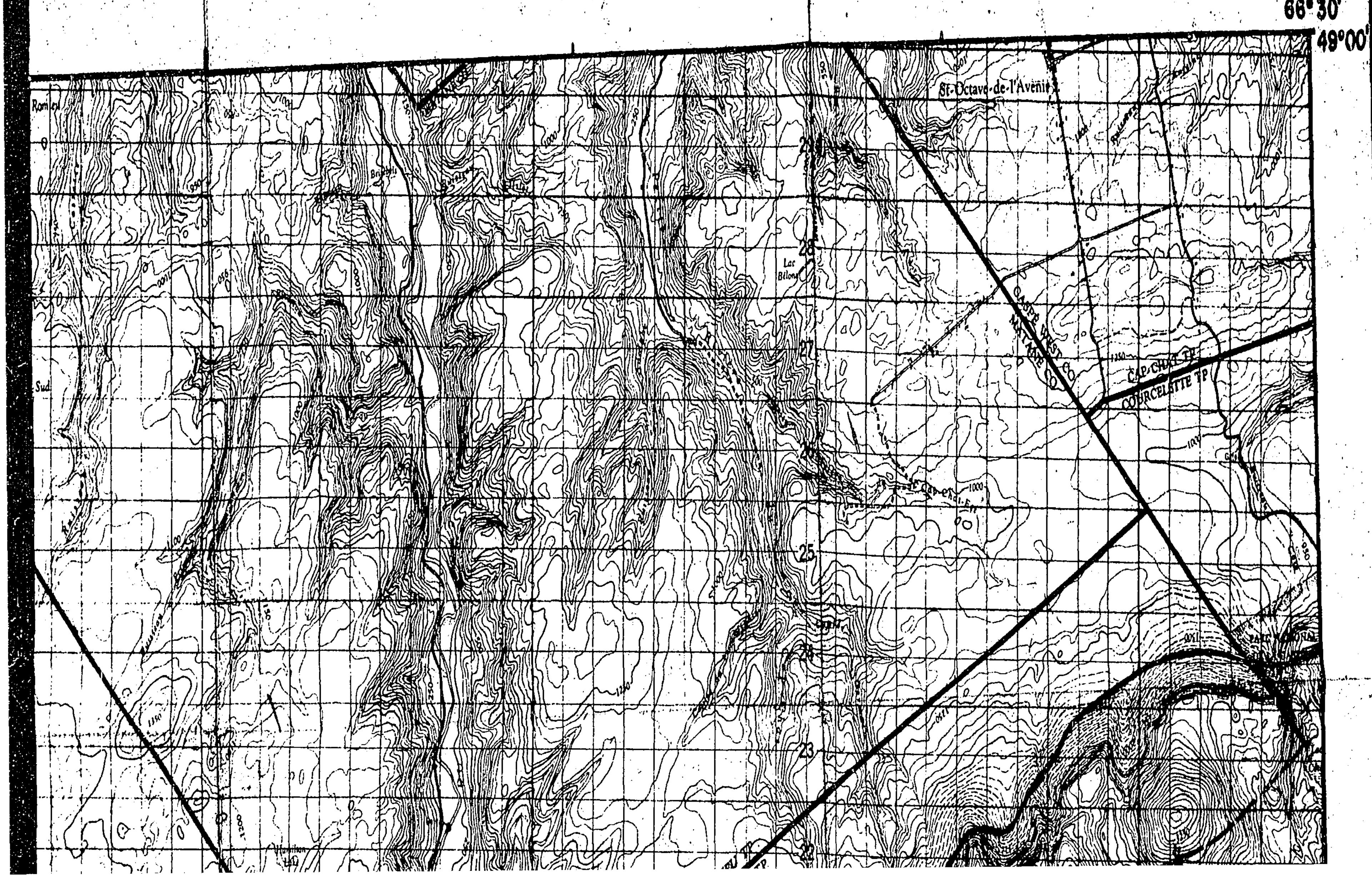
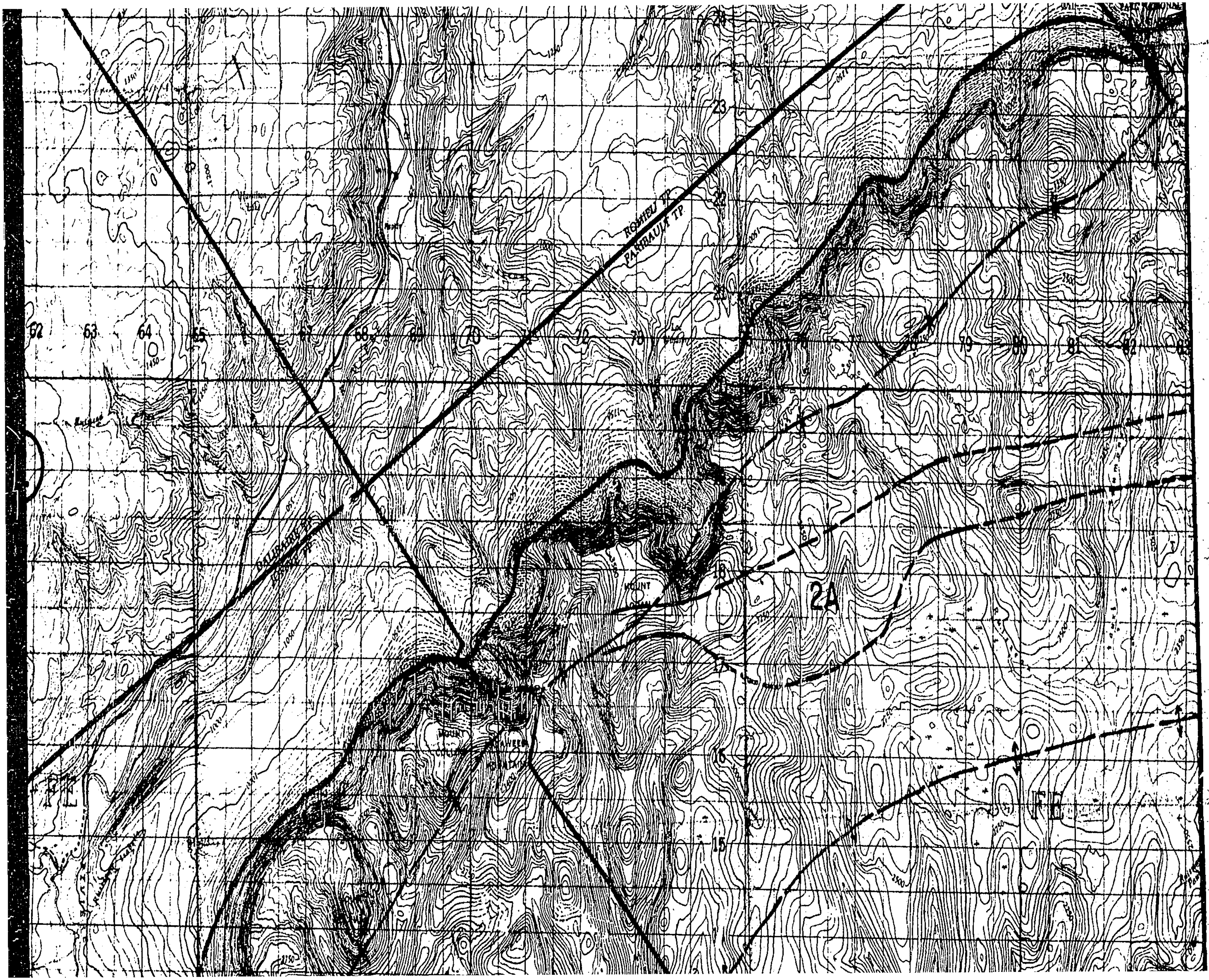


Figure D-4b

Sample computer card: input of frequencies of altitude shown on previous card.

MOUNT LOGAN Sheet.




2A
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ROSHEU TP.
PARBAULT TP.
MOUNT
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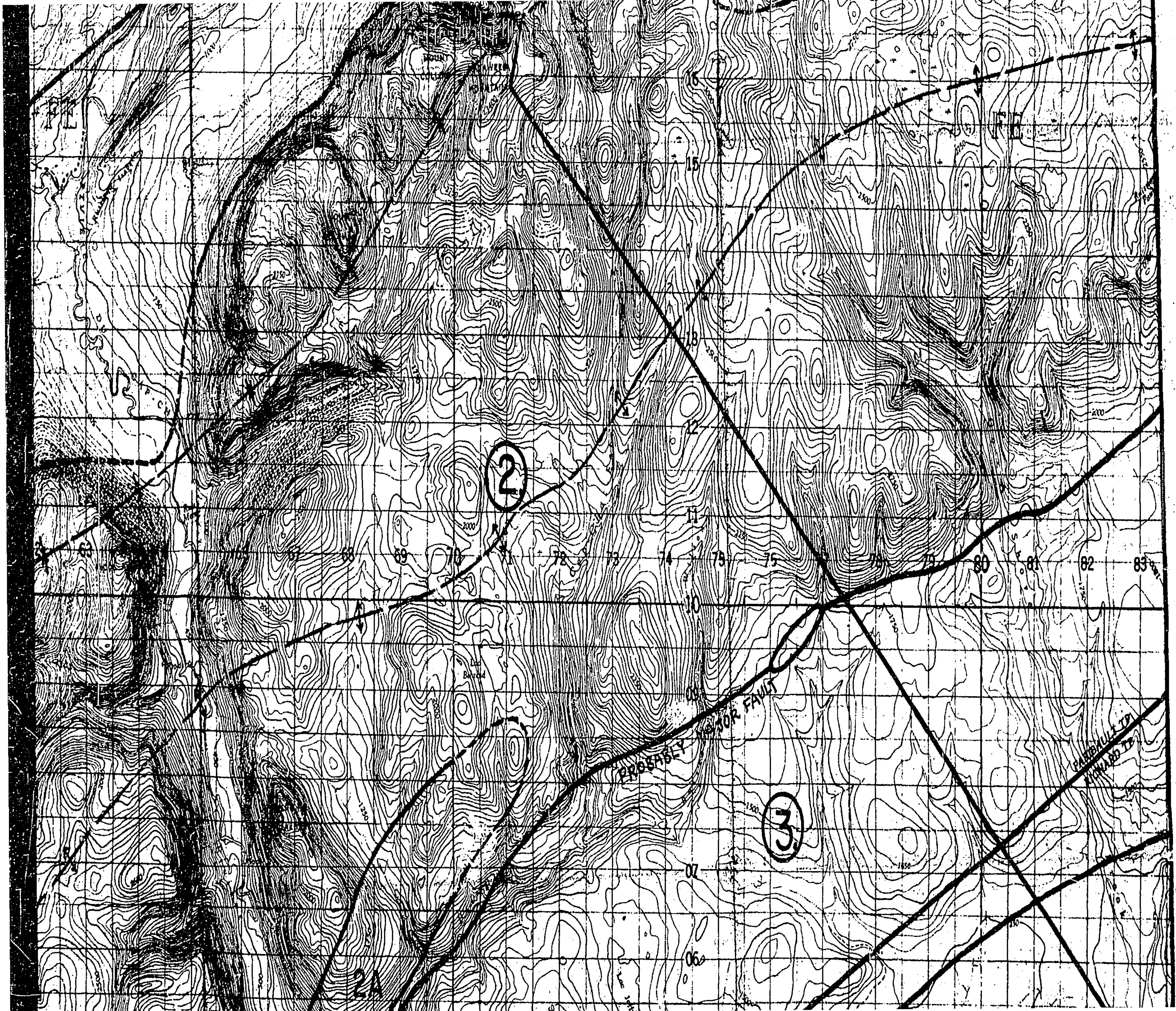

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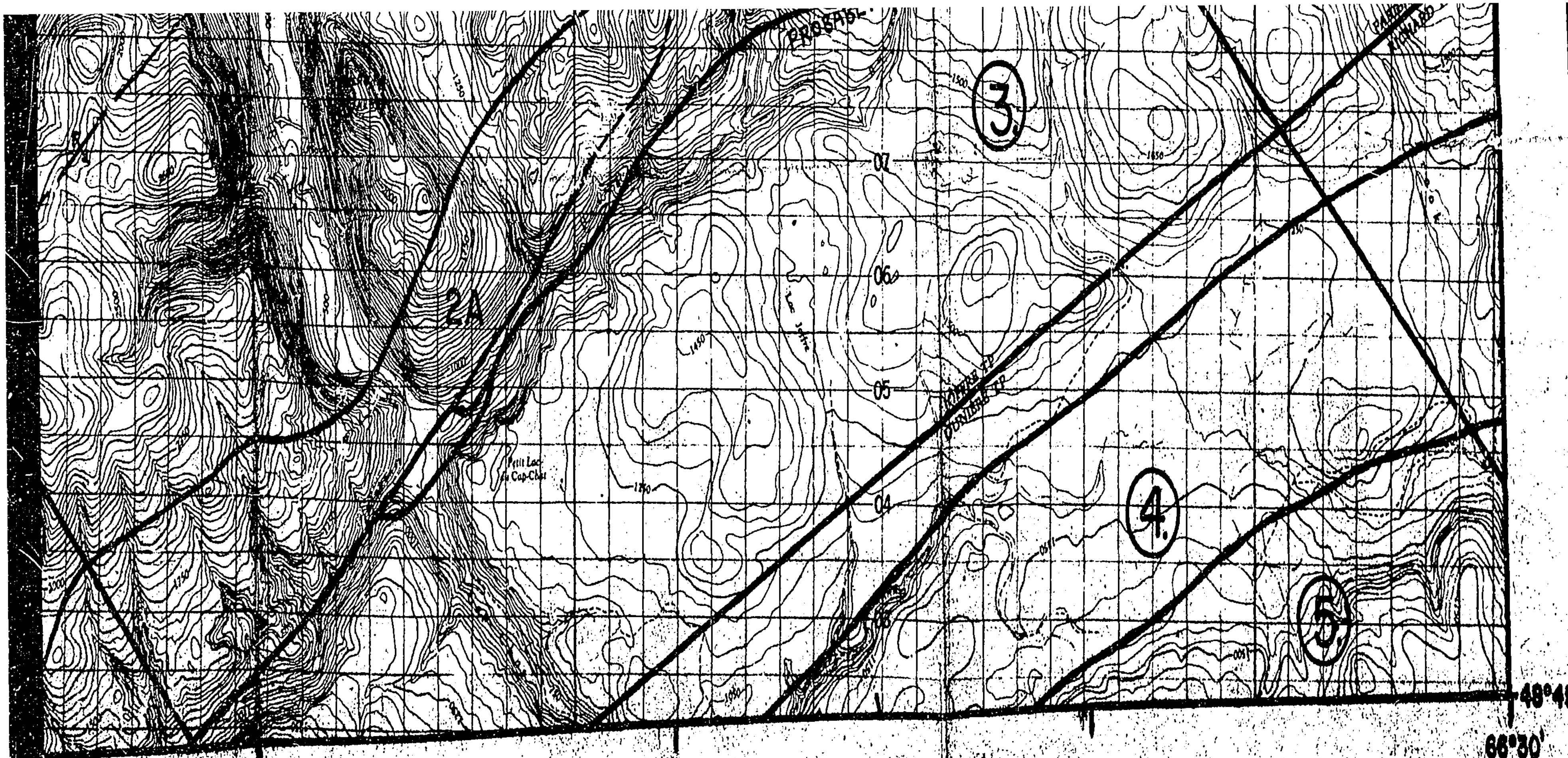


has no age connotation.

66°45'

Upper Silurian)
d limy and dolomitic
d shale.

Devonian)
ne, argillaceous to

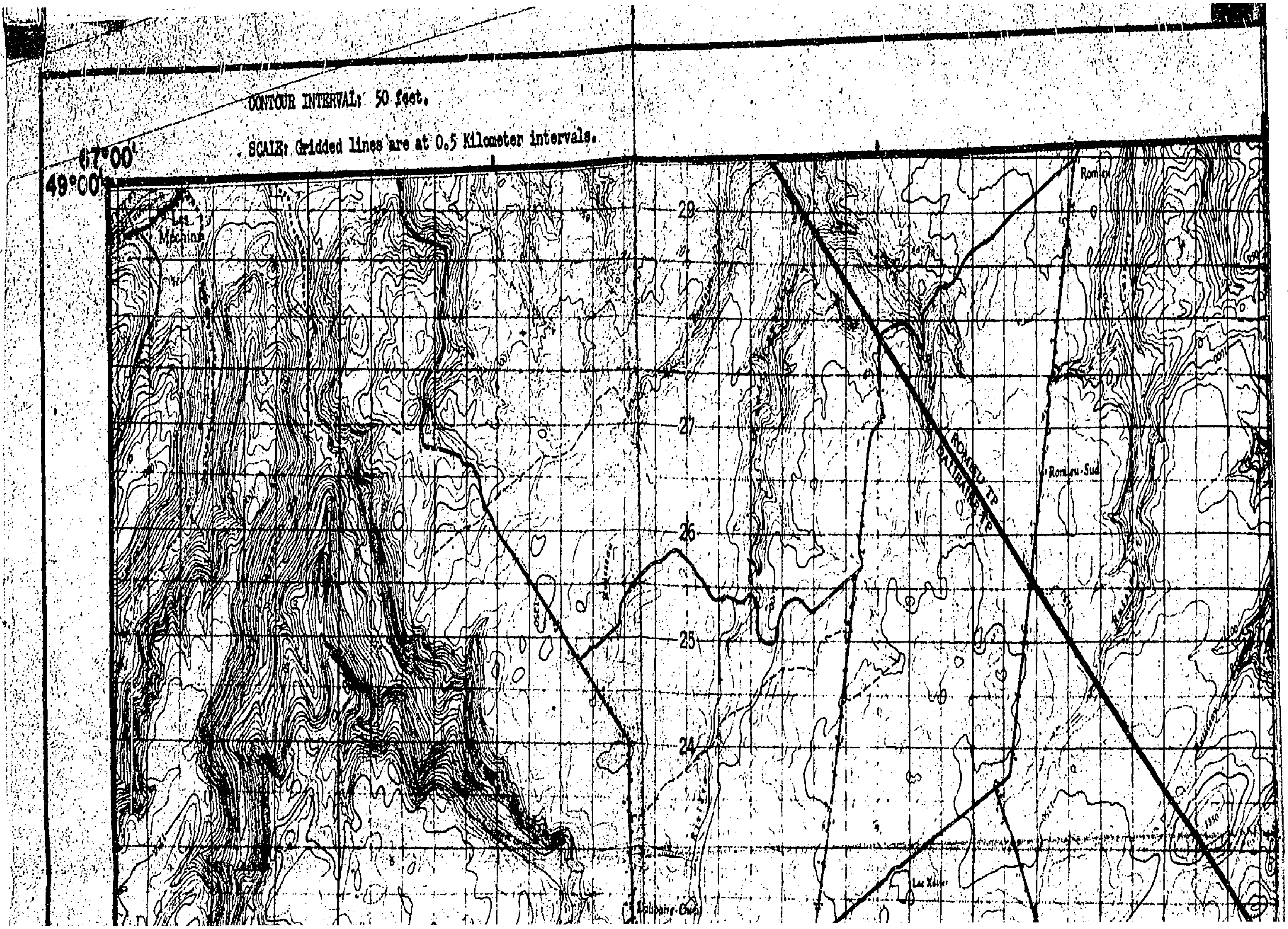
⑤	**Grande Grève Formation:** (Lower Devonian) Dark to medium grey, calcareous siltstone; minor dark grey shale.

Topographic base: Canadian National Topographic System Sheet 22-B-15.

Geology: Quebec Dept. Natural Resources, Geological Report no. 118.
(by C.R.Mattinson, 1964).

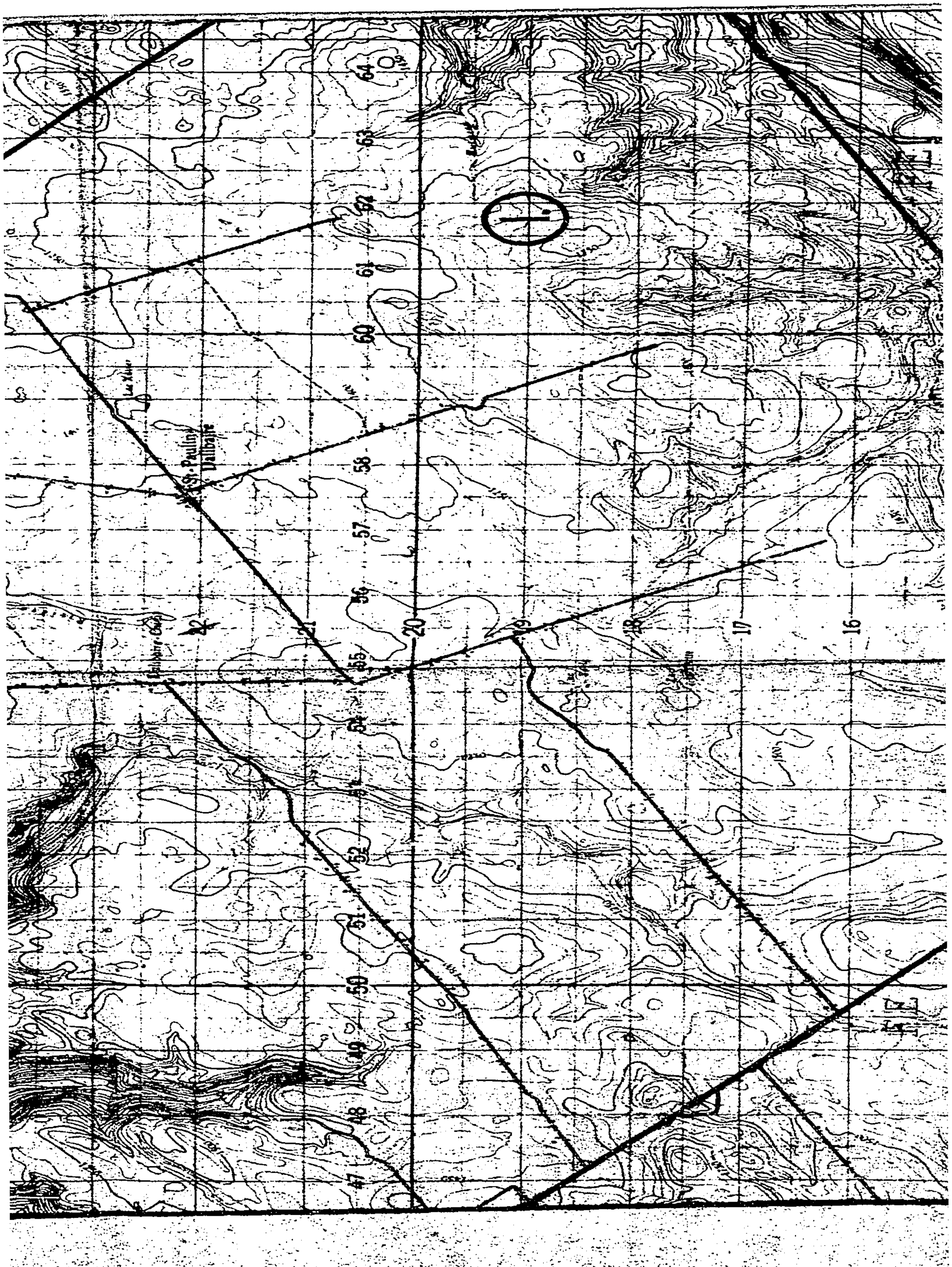
MAP NO. 1

J.J. [illegible] (1961)-[illegible]



CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.



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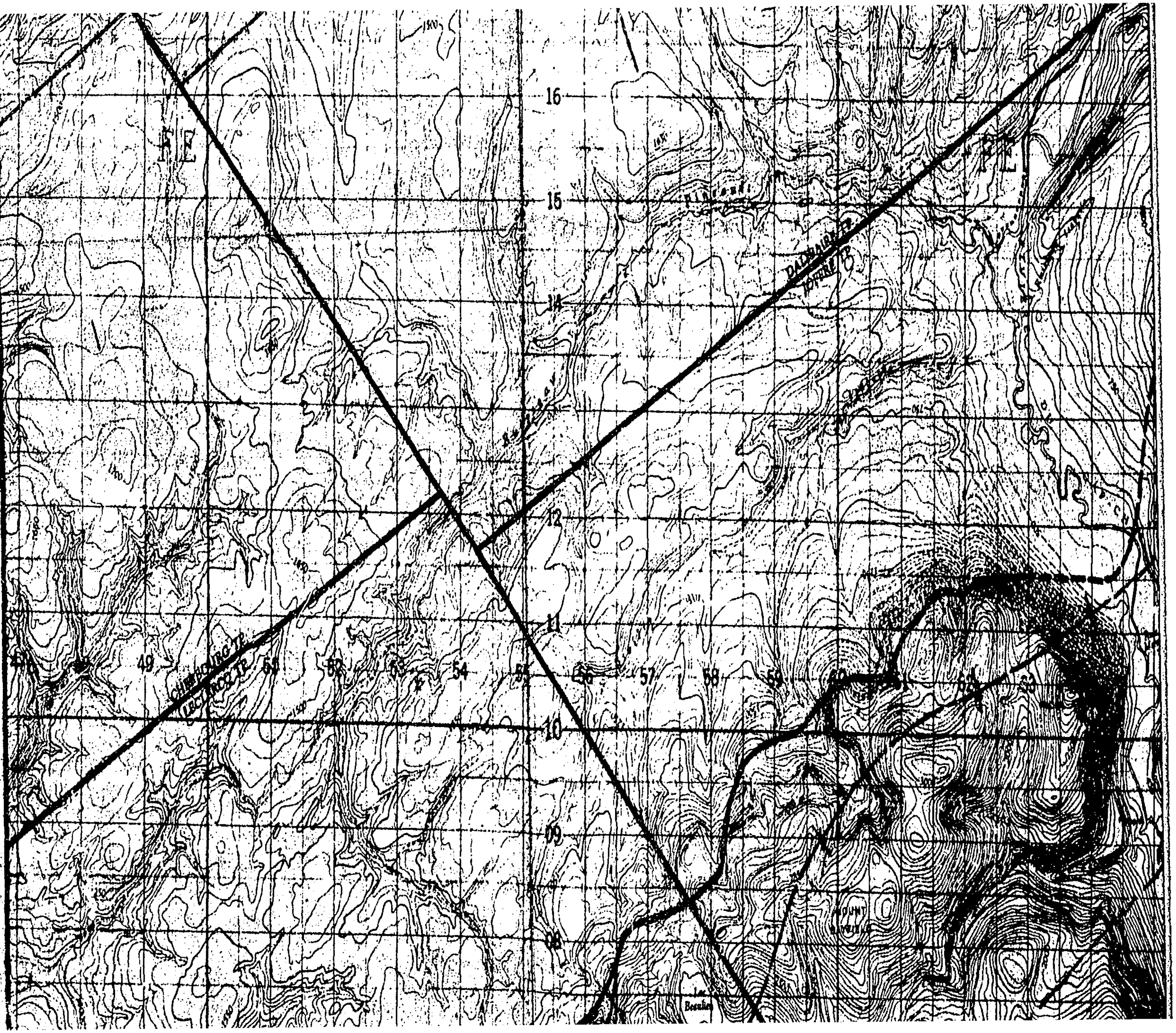

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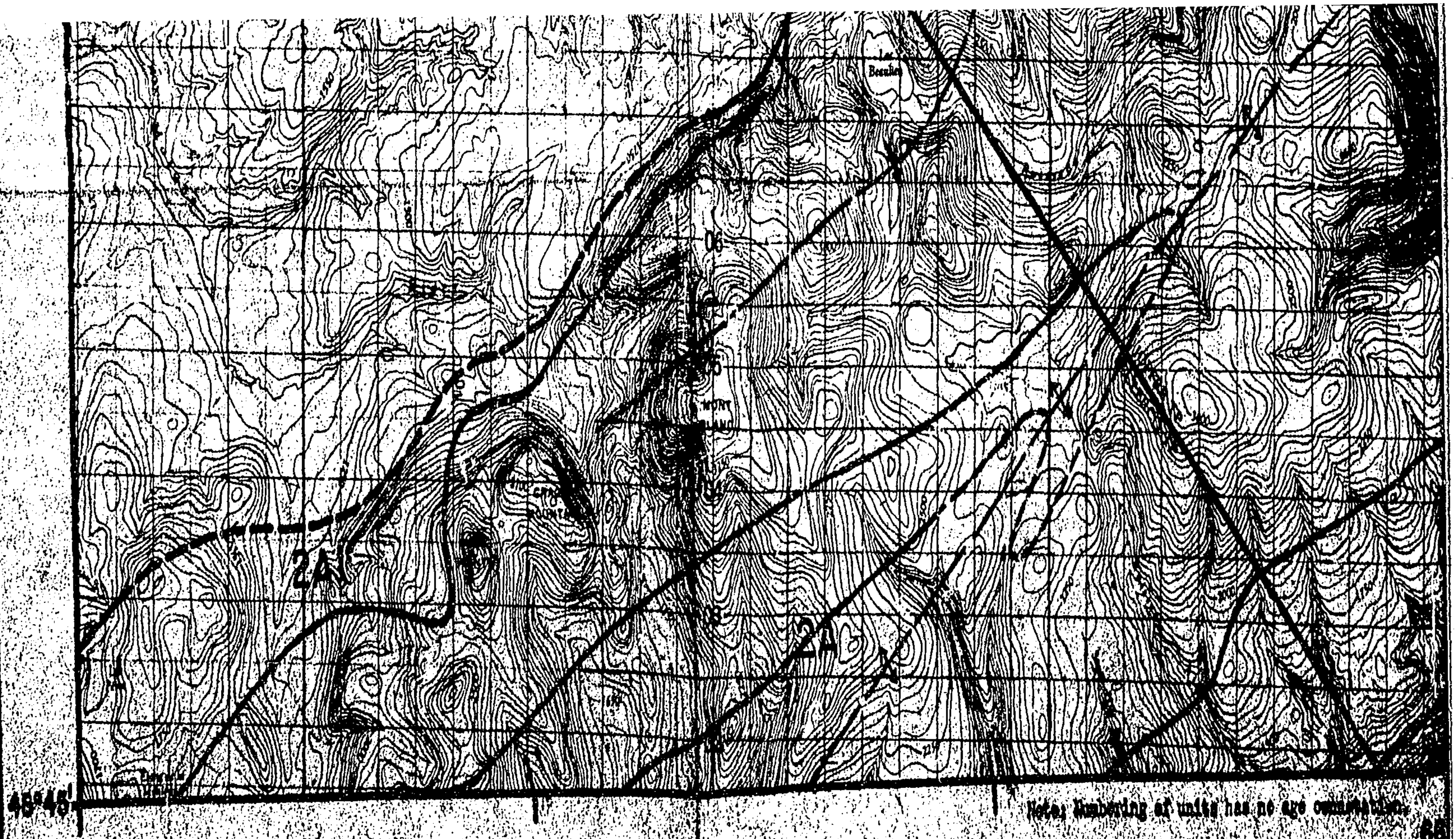


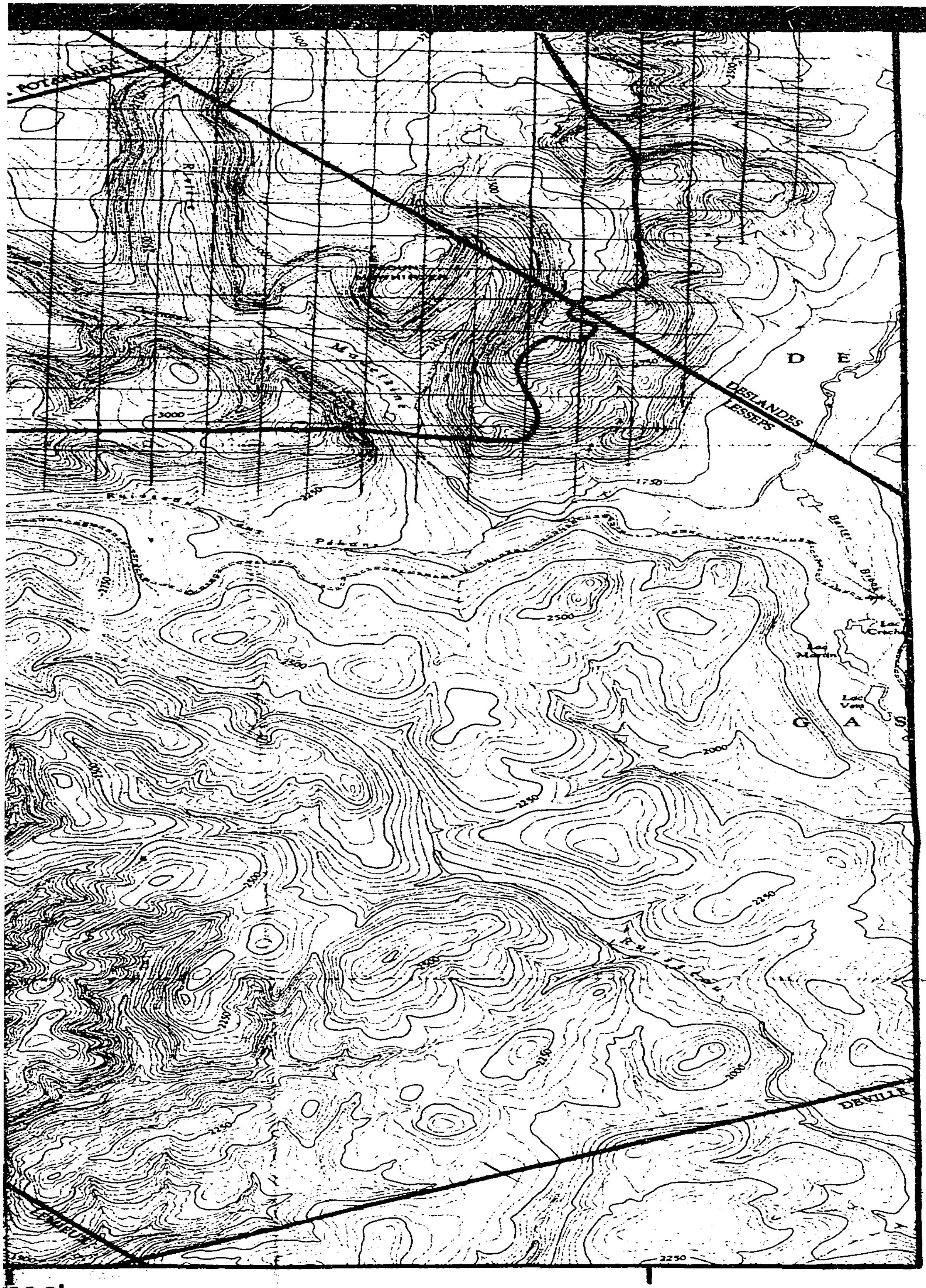
Note: Numbering of units has no age connotation.

① **Quebec Group:**
Highly fissile gray, red, and green slates, calcareous shales, and phyllites; sandstones, quartzites, limestones and conglomerates.

② **Shickshock Group** (Cambrian and-or Ordovician)
Metavolcanics; blue-green amphibolite schists (2); minor metasedimentary rocks (2A): quartz and finely micaceous schists.

③ **(Unnamed)** (Middle and Upper Silurian)
Gray limestone, fine grained limy and dolomitic clastics; minor dolomite and shale.

④ **Cape Bon Ami Formation** (Lower Devonian)
Dark gray, finely crystalline, argillaceous to silty limestone.



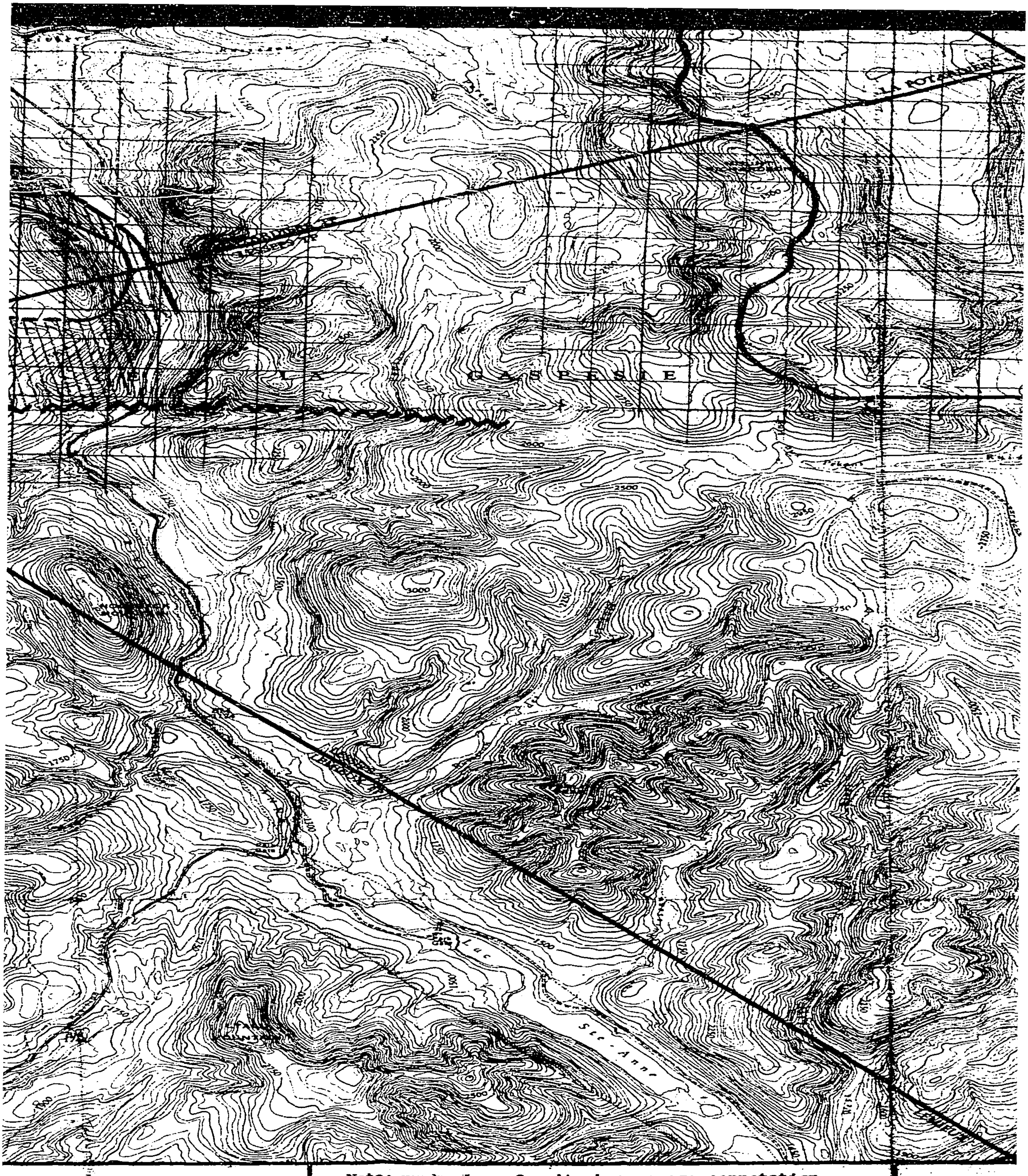
Topographic base: Canadian National Topographic System, combined sheets parts of 22-A-13 (West) and 22-B-16 (East).

Geology:

1. Geological Survey of Canada, Memoir no. 144 (by F.J.Alcock, 1926);
2. Quebec Dept. Mines (Natural Resources), Annual Report for 1932, part-D, (by I.W.Jones, 1933).

MAP NO: 2.

J.J.Raudsepp (1967)-Lithology and altitude in Gaspé Peninsula.



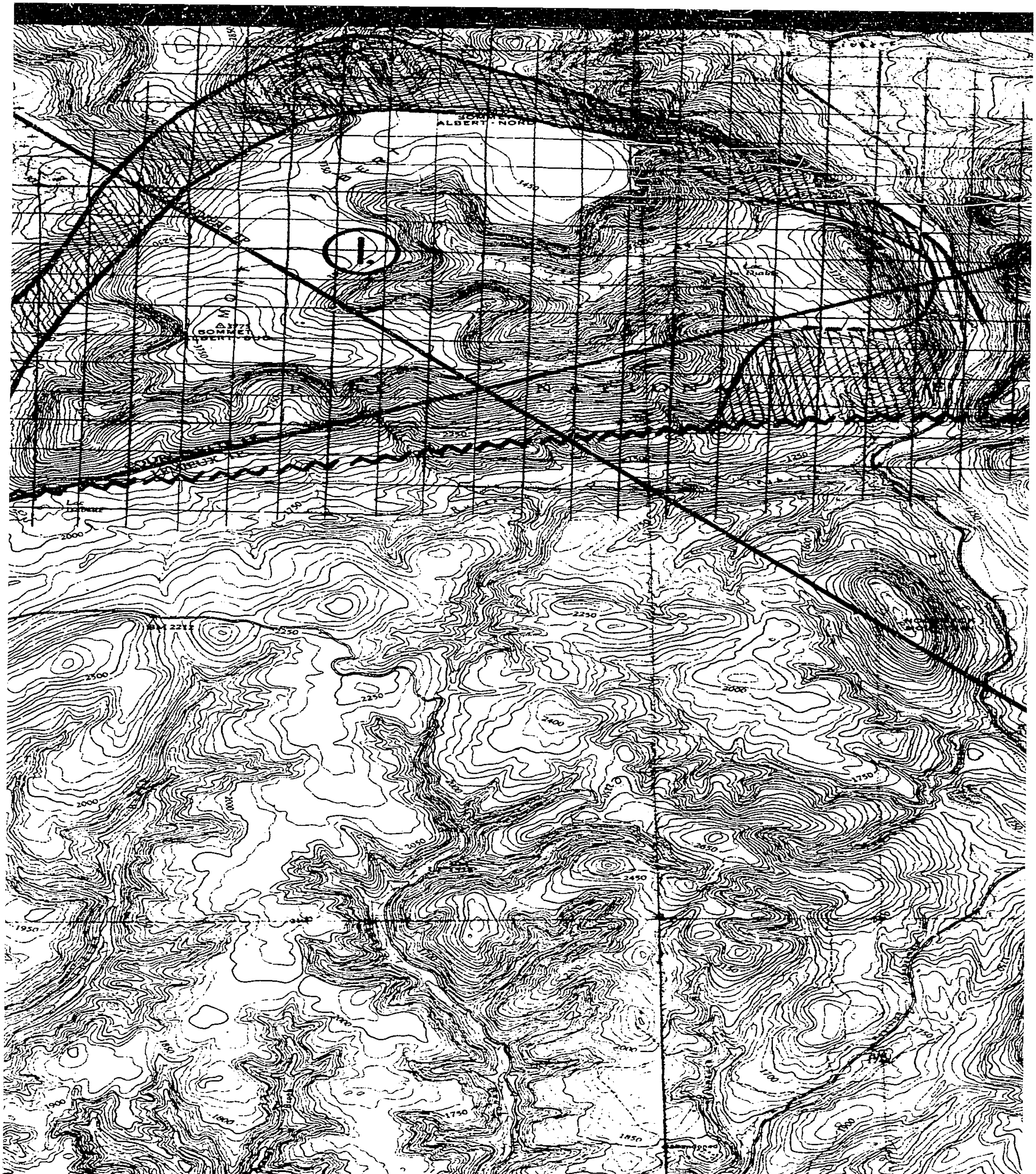
Note: numbering of units has no age connotation.

②

Tabletops Granite Intrusive: (Devonian)
Medium to coarse grained, pink to red granite; Light to dark grey, medium grained, locally porphyritic diorite (xenoliths); and granodiorite; syenite; minor dykes of fine grained to sugary, pink felsite, pegmatite, and granite porphyry.

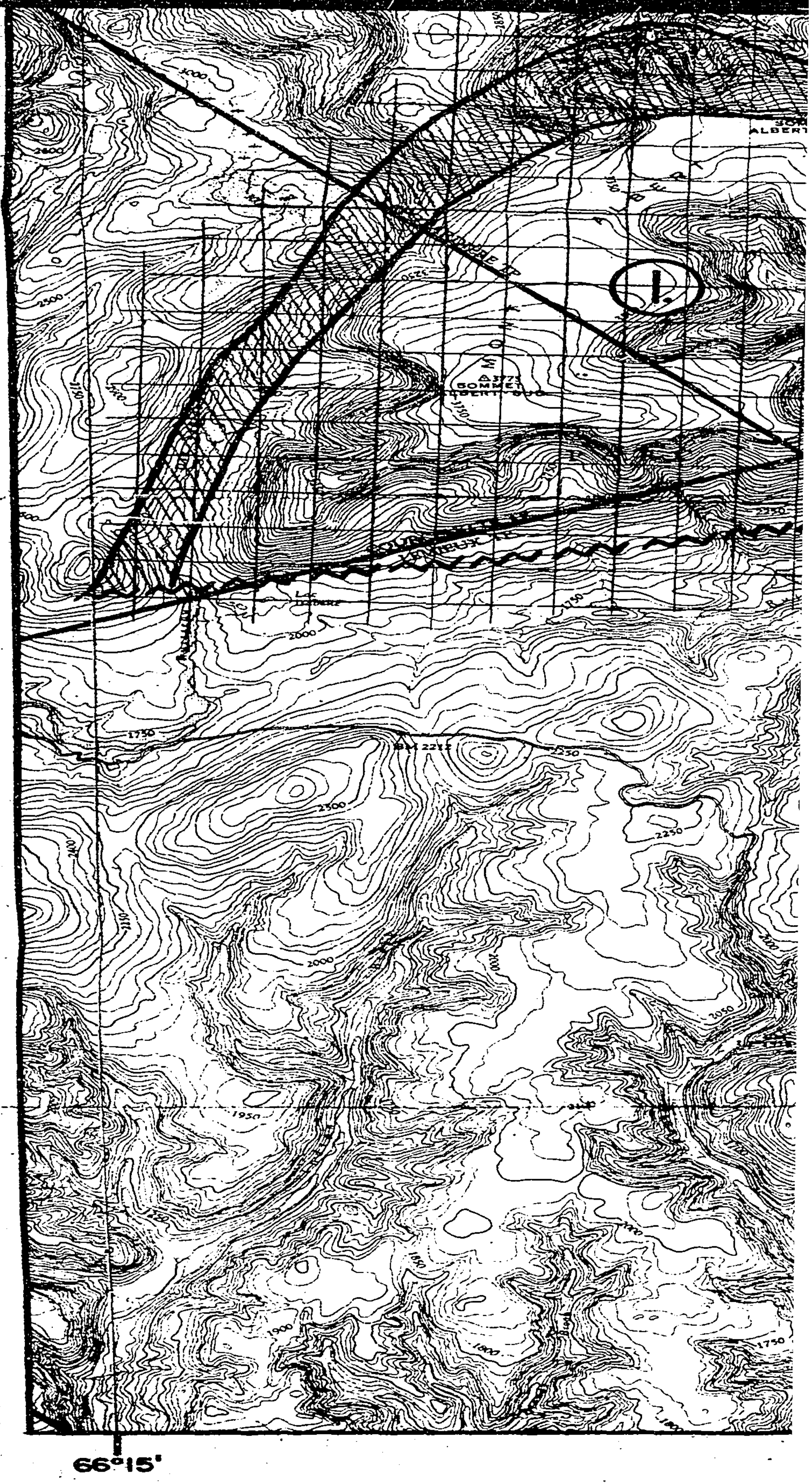
Topog
Geolog

1962.)



① **Mt. Albert Ultrabasic Intrusive:** (Ordovician)
Yellowish green to almost black dunite, peridotite;
minor pyroxenite, serpentinite, chromitite.
Bordered by contact metamorphic rim consisting of
rocks of granulite, almandite-amphibolite, and
epidote-amphibolite facies.

(Note: Detailed description in MacGregor, 1962.)

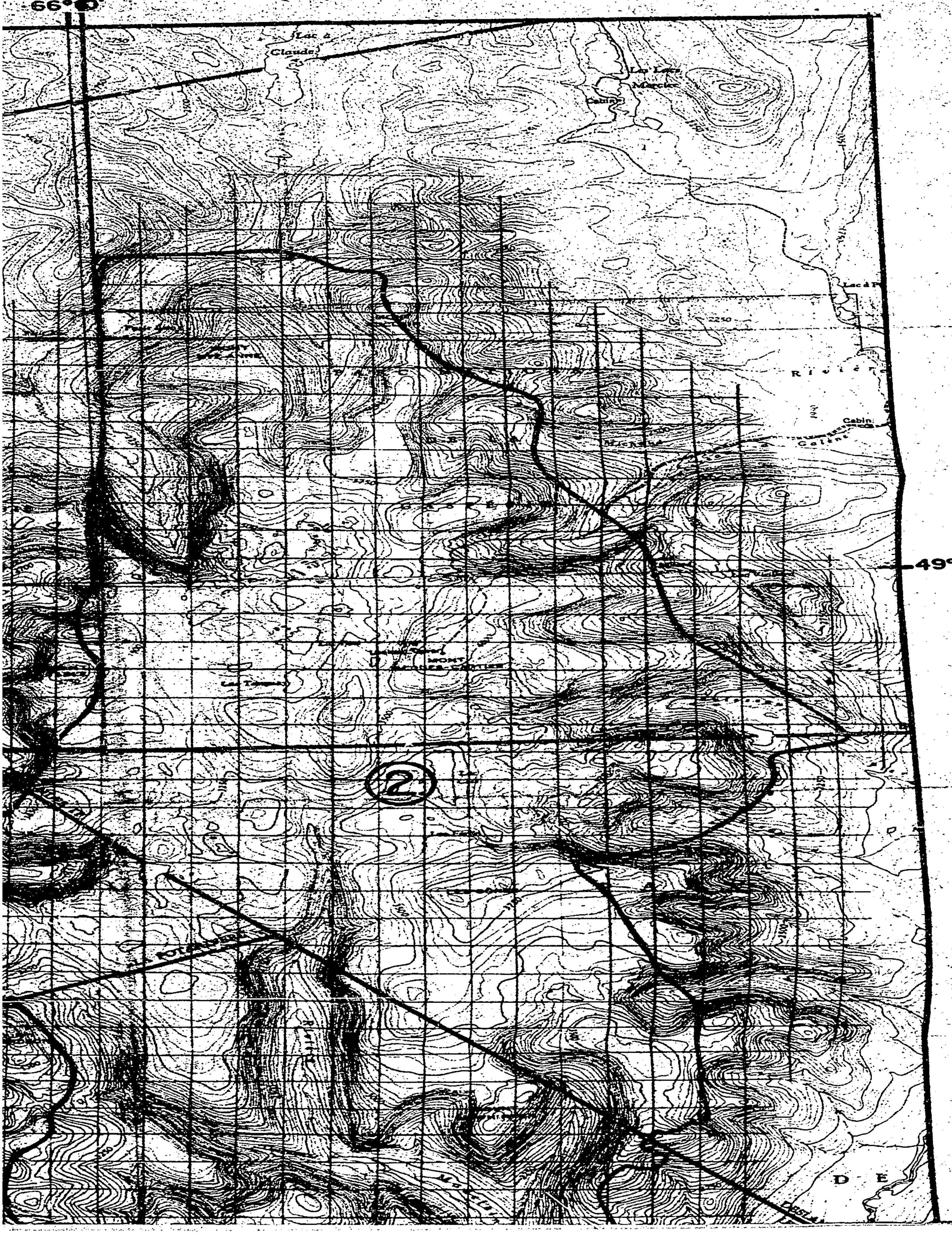


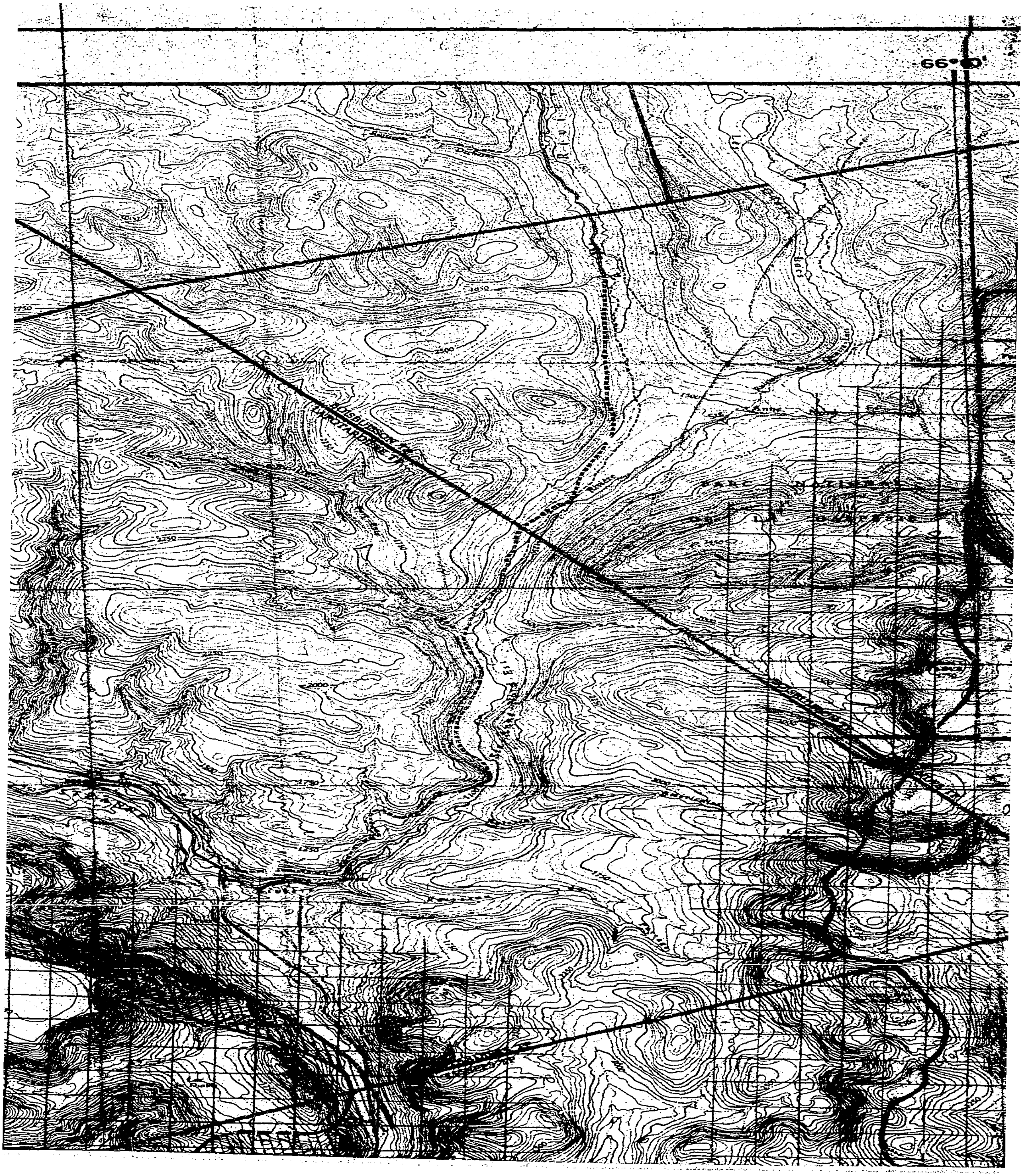
①

Mt. Albert Ultrabasic
Yellowish green to
minor pyroxenite,
Bordered by contac
rocks of granulite
epidote-amphibolit

(Note: De

MONT ALBERT and TABLETOPS




66°0'
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DE LA GASPÉSIE
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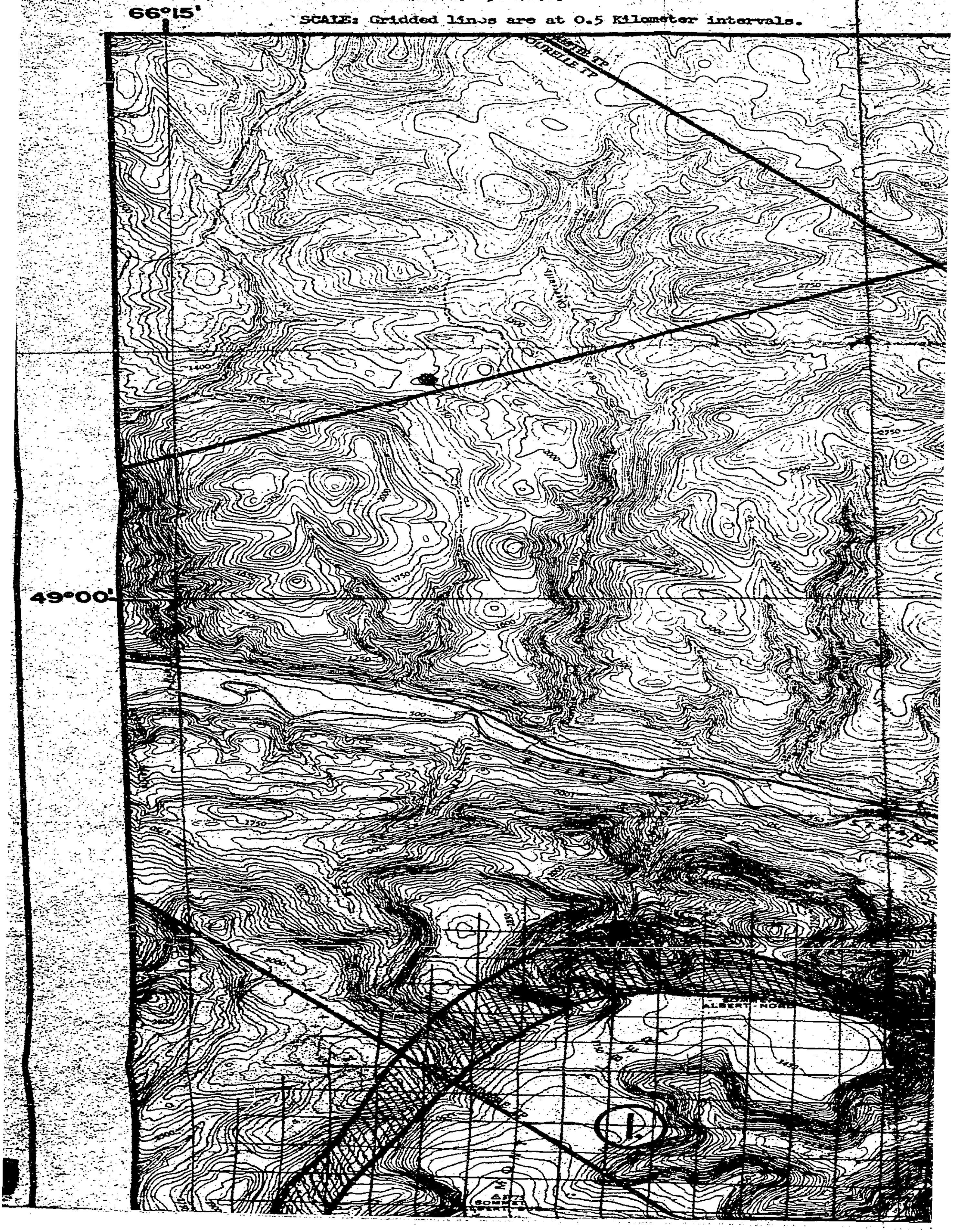
CONTOUR INTERVAL: 50 feet.

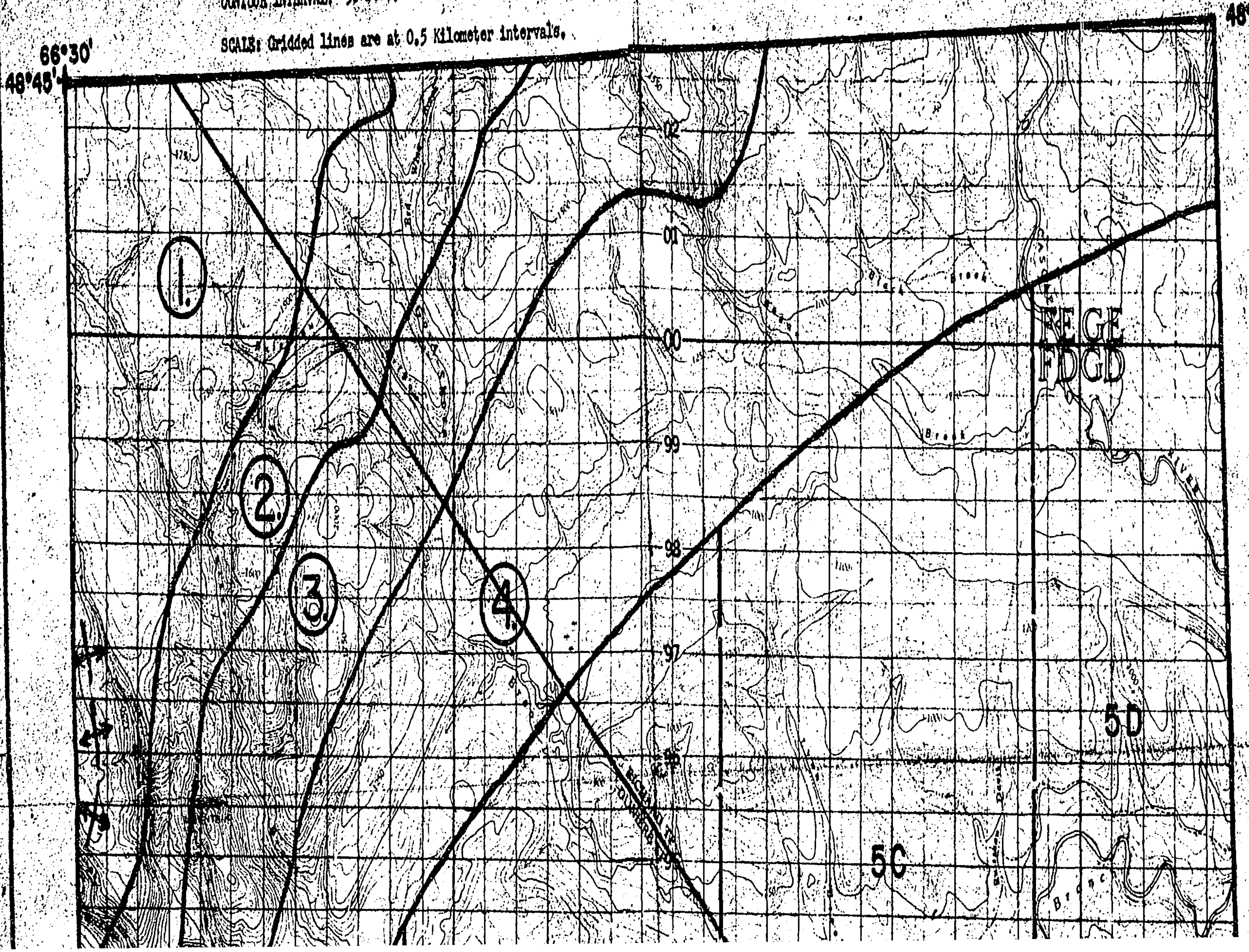
SCALE: Gridded lines are at 0.5 Kilometer intervals.

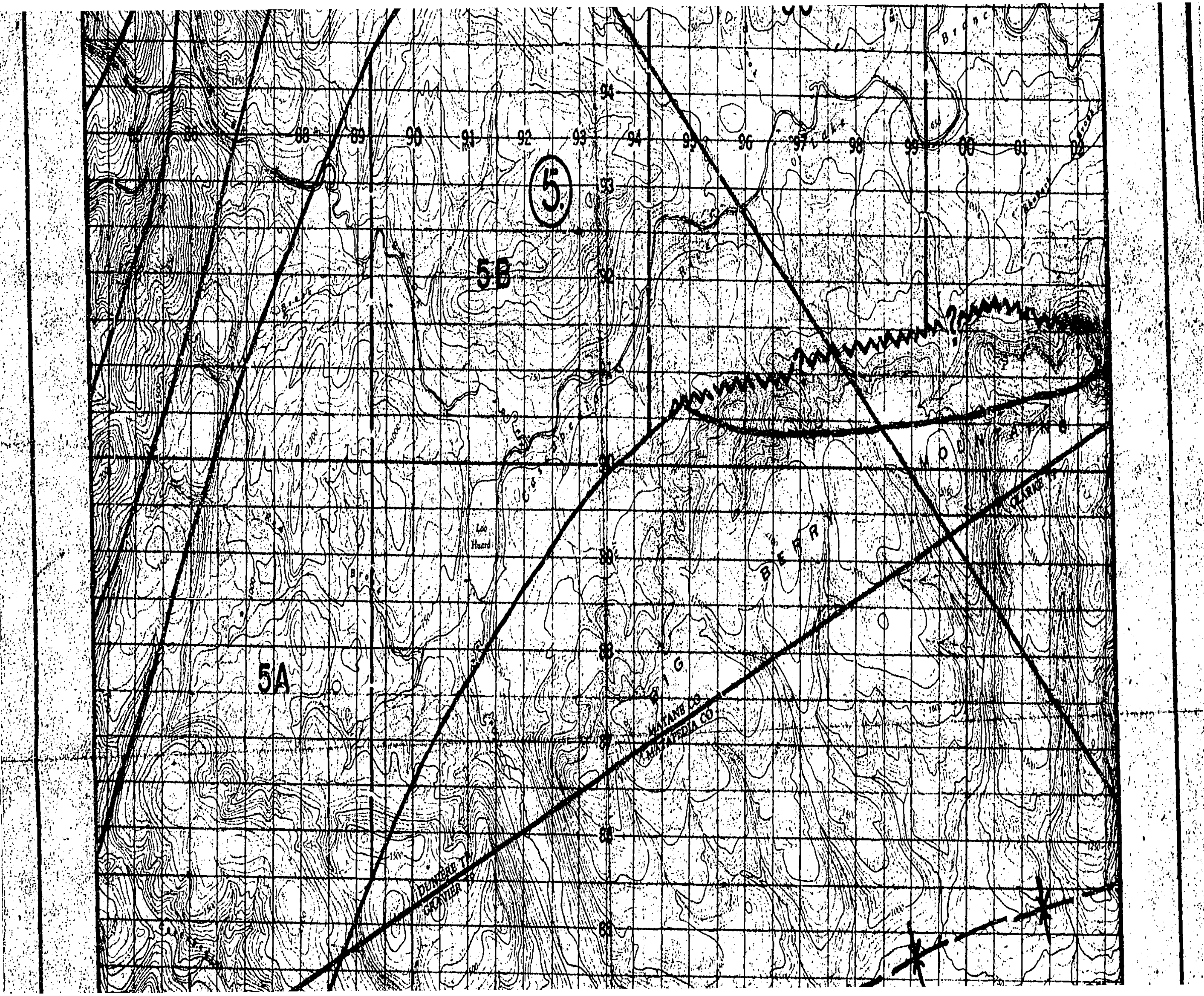


BIG BERRY MOUNTAINS W/2 Sheet.

CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.

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BIG BERRY MOUNTAINS
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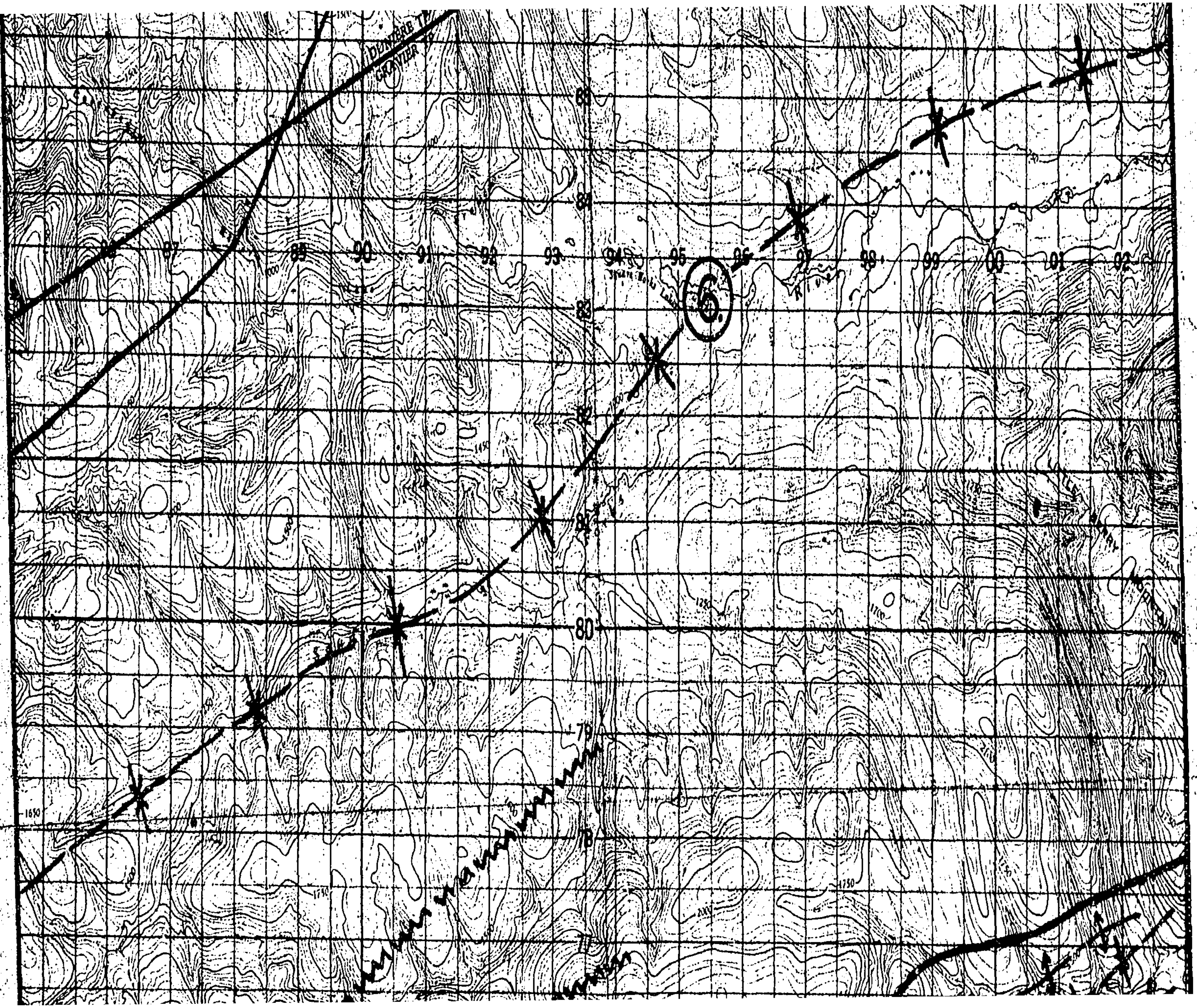
MATAPEDIA CO
Lac Huard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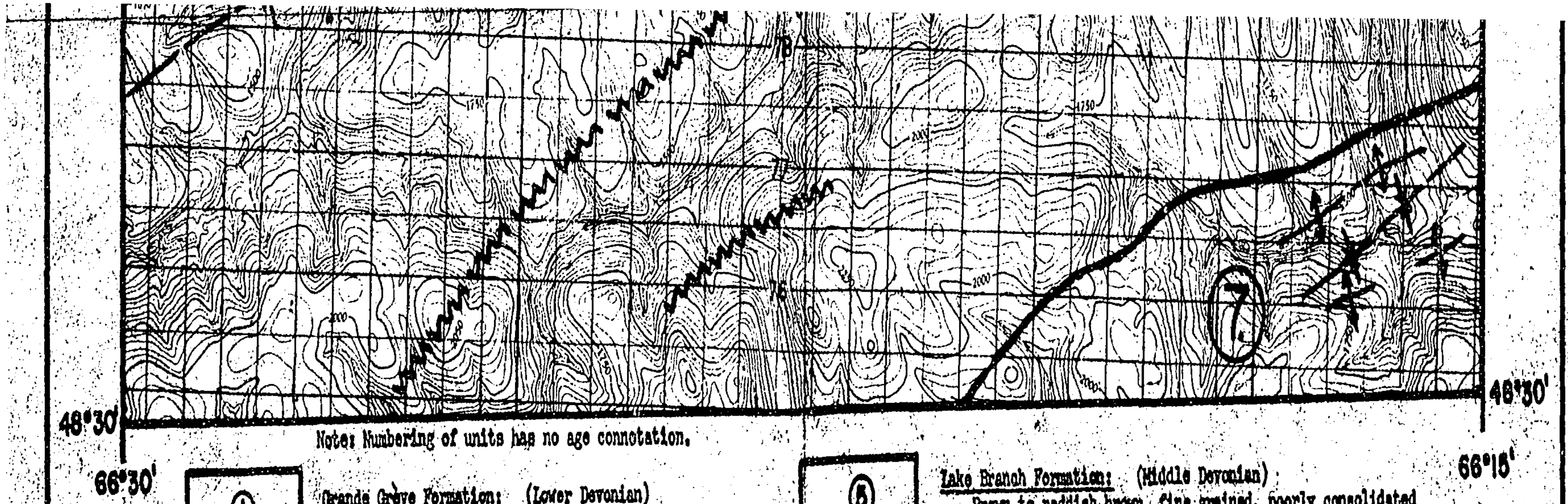


Note: Numbering of units has no age connotation.

① **Grande Greve Formation:** (Lower Devonian)
Dark to brownish grey, hard brittle, calcareous siltstone and siliceous limestone.

② **York Lake Facies (of York River Formation):** (Lower Devonian)
Interbedded feldspathic sandstone, similar to the York River Formation, and limestone and shale, similar to the Grande Greve Formation.

③ **Volcanic Rocks:** (Lower Devonian)
Basic lavas: amygdaloidal andesite, basalt, olivine basalt, and andesite porphyry.

④ & ⑦ **York River Formation:** (Lower or Middle Devonian)
Greenish grey, medium to fine grained feldspathic sandstone with interbeds of greenish grey shale (estimated up to 35%).

⑤ **Lake Branch Formation:** (Middle Devonian)
Brown to reddish brown, fine grained, poorly consolidated sandstone and shale; local interbeds of green, medium grained, hard calcareous sandstone.

⑥ **Battery Point Formation:** (Lower or Middle Devonian)
Medium to light greenish grey, fine to very coarse grained greywacke sandstone, with interbeds of grey shale (estimated up to 20%).

Topographic base: Canadian National Topographic System, Sheet no: 22-B-9 (West).
Geology: Quebec Dept. Mines (Natural Resources), Geological Report no. 90; (by C. Carbonneau, 1959).

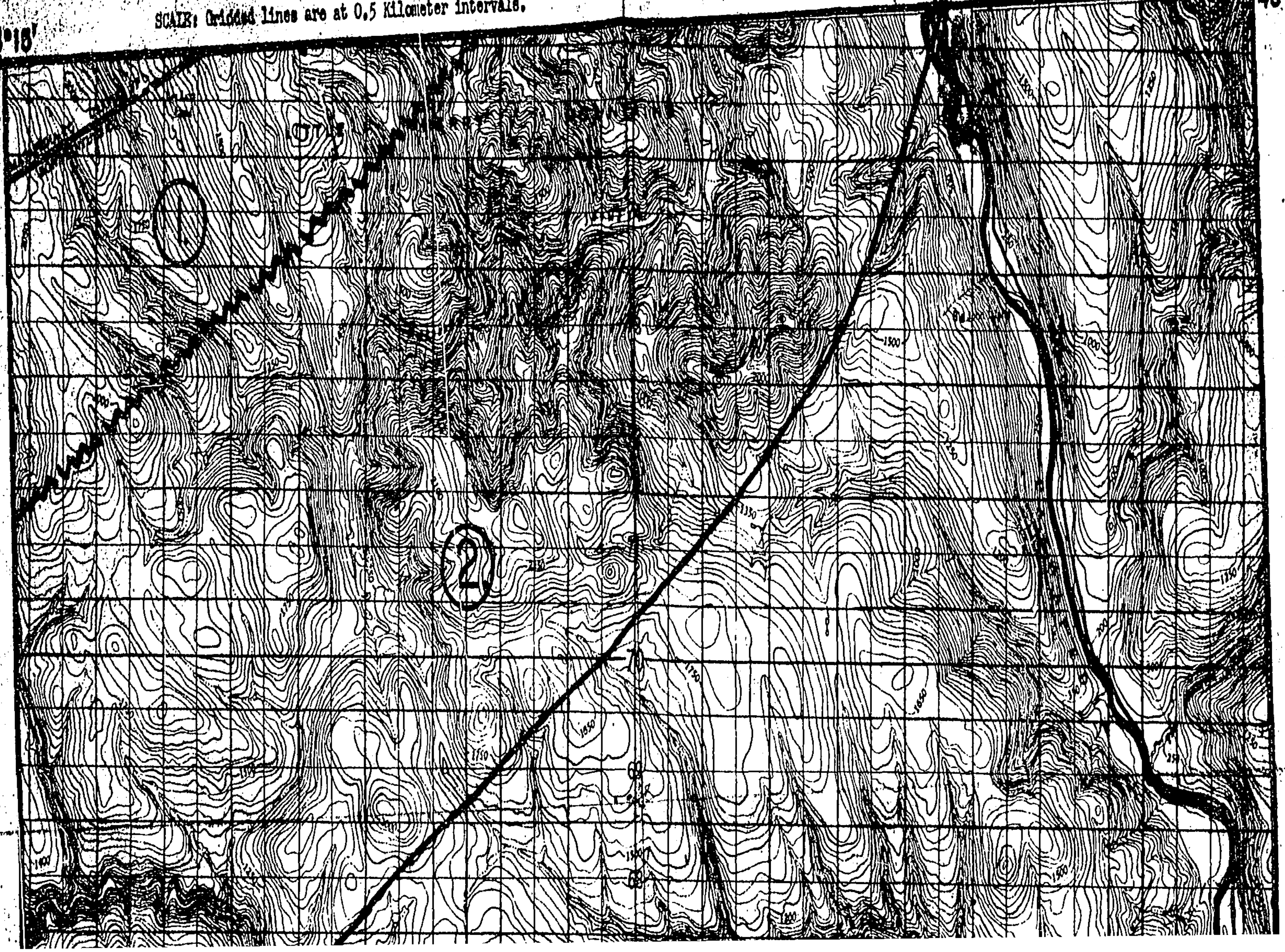
MAP NO. 3.

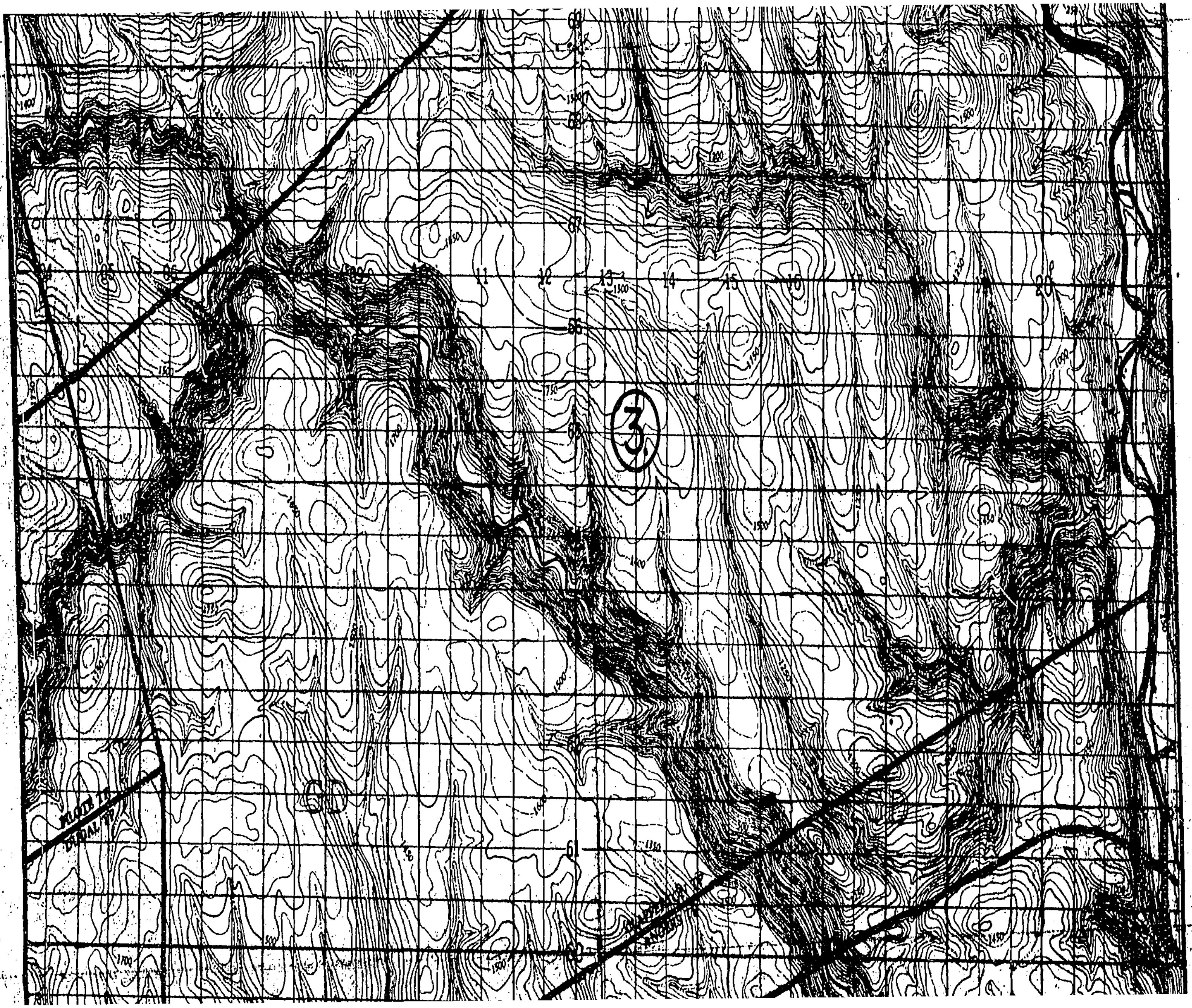
J.J.Bandsepp (19[illegible]7)-[illegible]

RIVIERE ANGERS E/2 Sheet.

CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.

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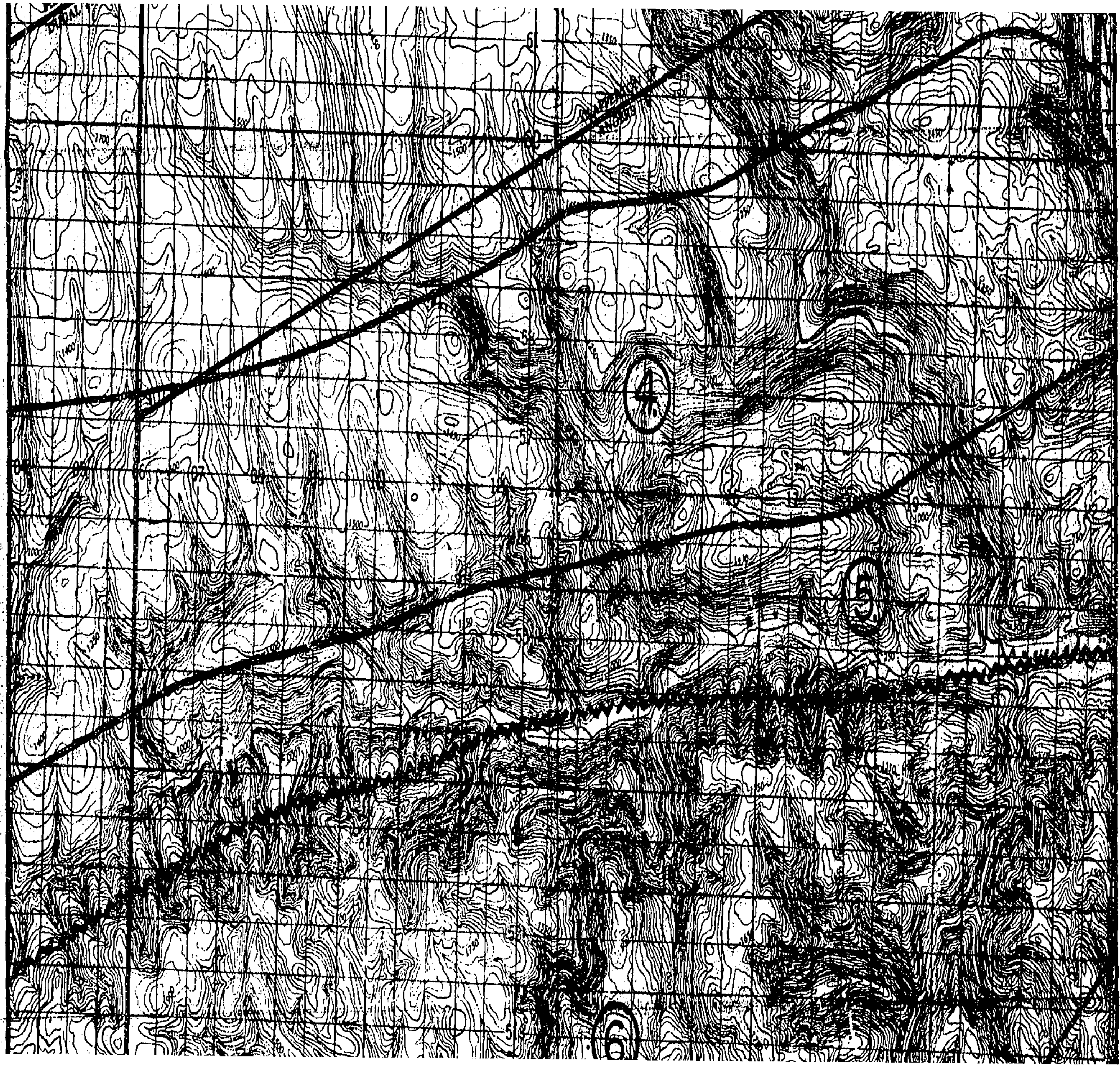
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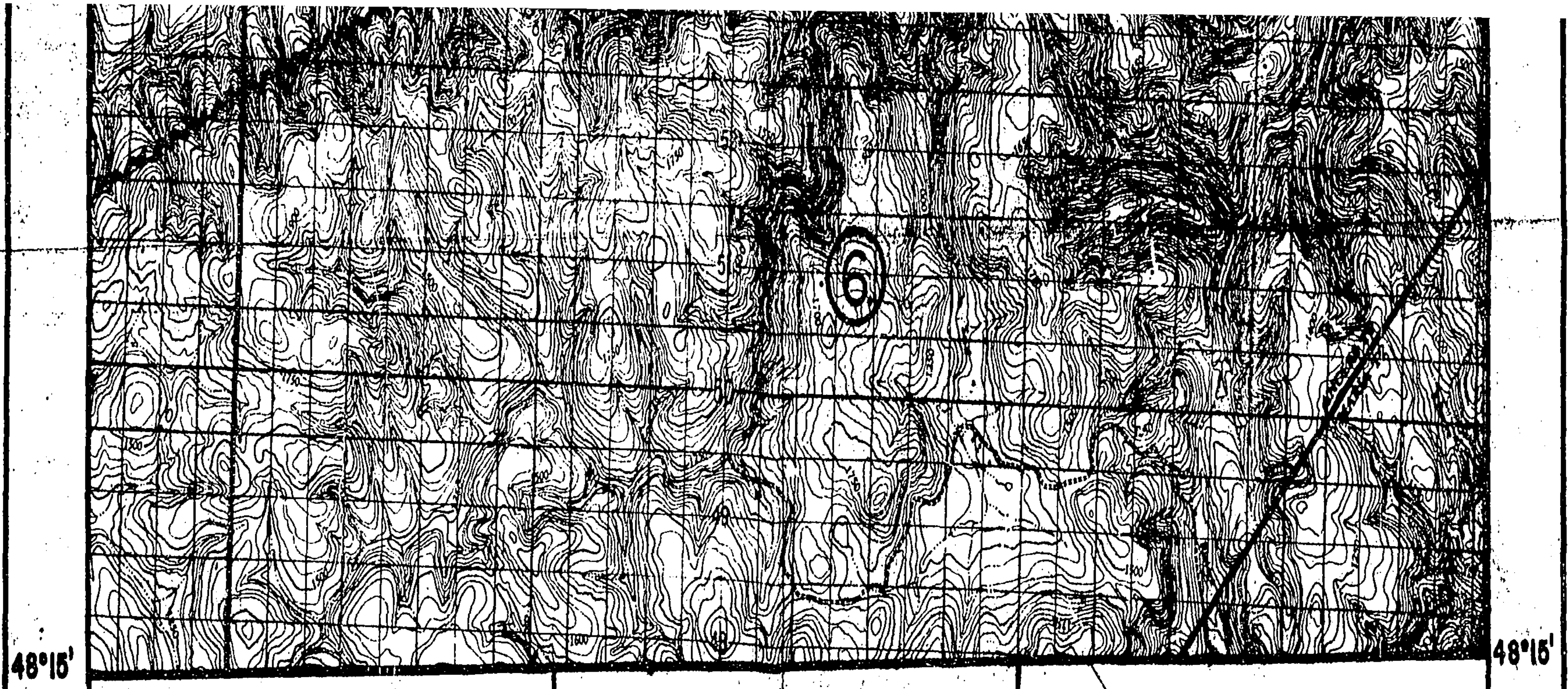


① York River Formation: (Middle Devonian)
Greenish grey, medium to fine grained feldspathic sandstone; with minor interbedded greenish grey, silty shale.

② Jonathan Formation: (Upper Silurian)
Medium to fine grained amygdaloidal to porphyritic, generally ophitic andesite, interbedded with thin zones of hard, acidic tuffs; minor siltstones.

③ Fortin Group: (Lower Devonian)
Undifferentiated dark grey slate and argillaceous limestone; minor feldspathic sandstone and conglomerate.

④ Mont Alexandre Group: (Upper and Middle Silurian)
Undifferentiated volcanic rocks (basic to intermediate lavas), and grey siltstones; minor limestone, conglomerate, tuffs and agglomerate.

⑤ Matapedia Group: (Ordovician and Lower Silurian)
Light to medium grey limestone, and grey. calcareous shale.

⑥ Honorat Group: (Ordovician)
Grey, fine to medium grained sandstone and mudstone; minor conglomerate and grey limestone.

Topographic base: Canadian National Topographic System Sheet 22-B-8 (East).
Geology: Quebec Dept. Natural Resources Interim Report (Geological), Manuscript (by W.B.Skidmore, 1960).

Note: Numbering of units has no [illegible] connotation.

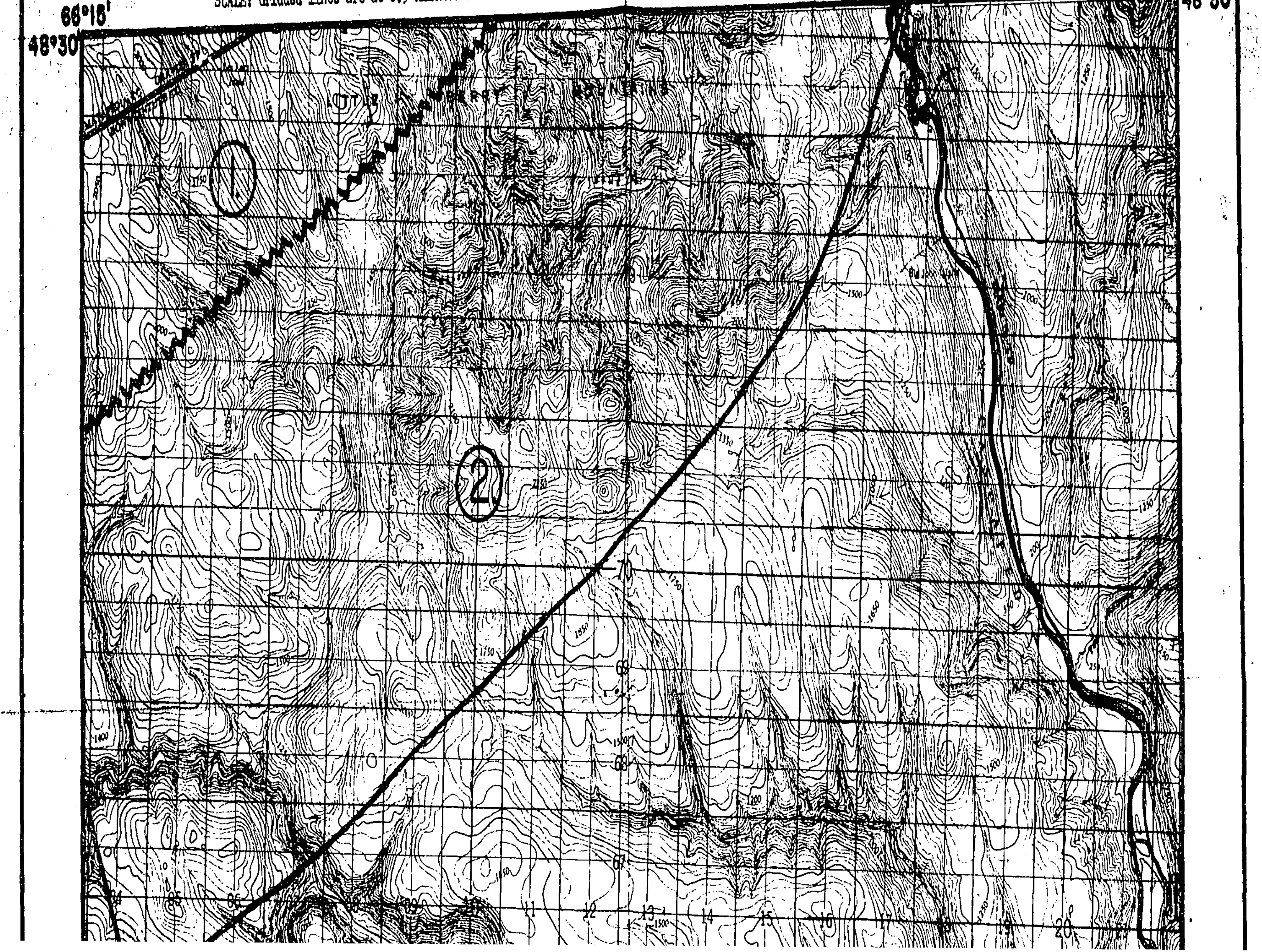
MAP NO: 4.

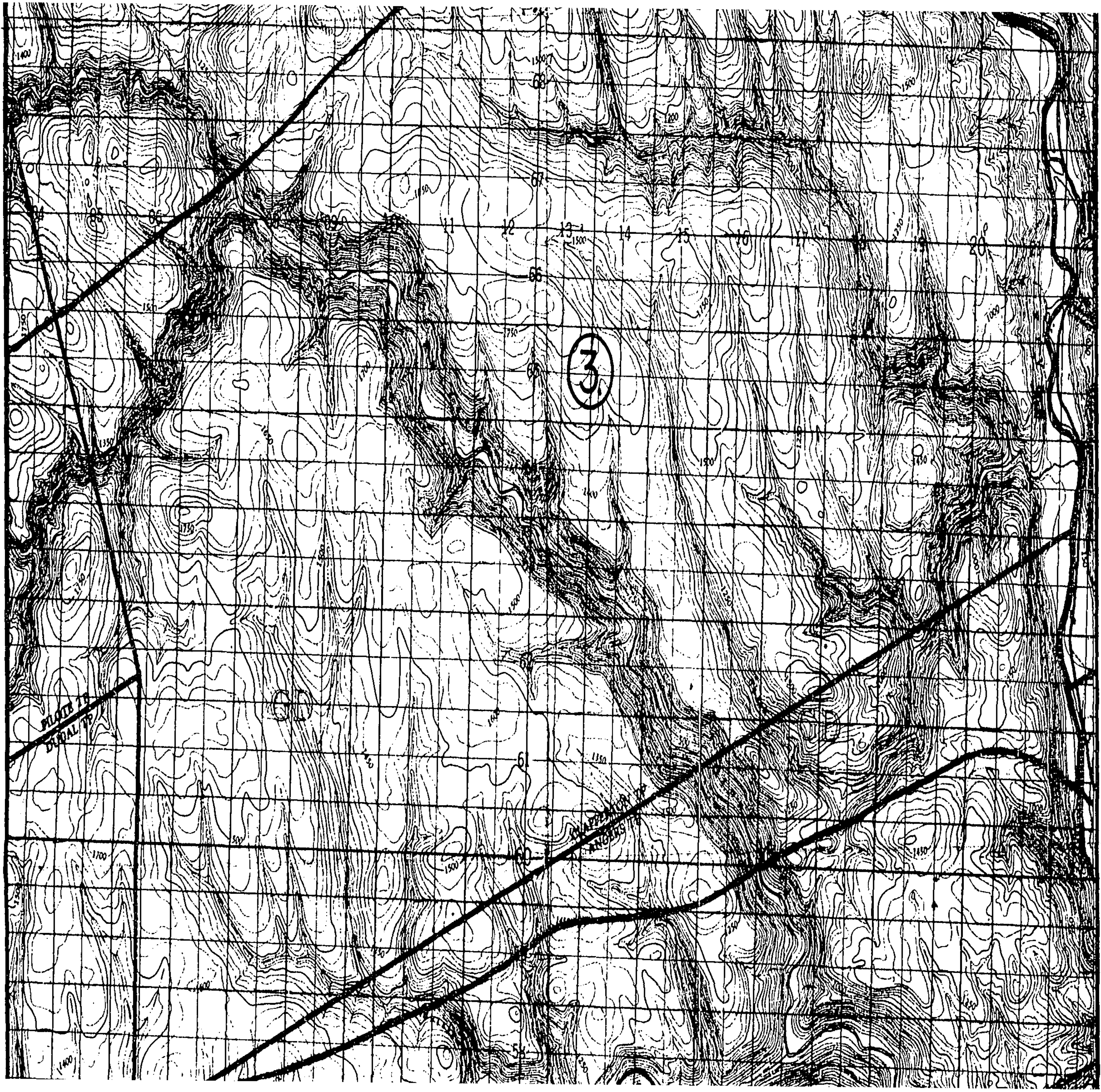
J.J.Raudsepp (1967)-Lithology and altitude in Gaspé Peninsula.

RIVIERE ANGERS E/2 Sheet.

CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.

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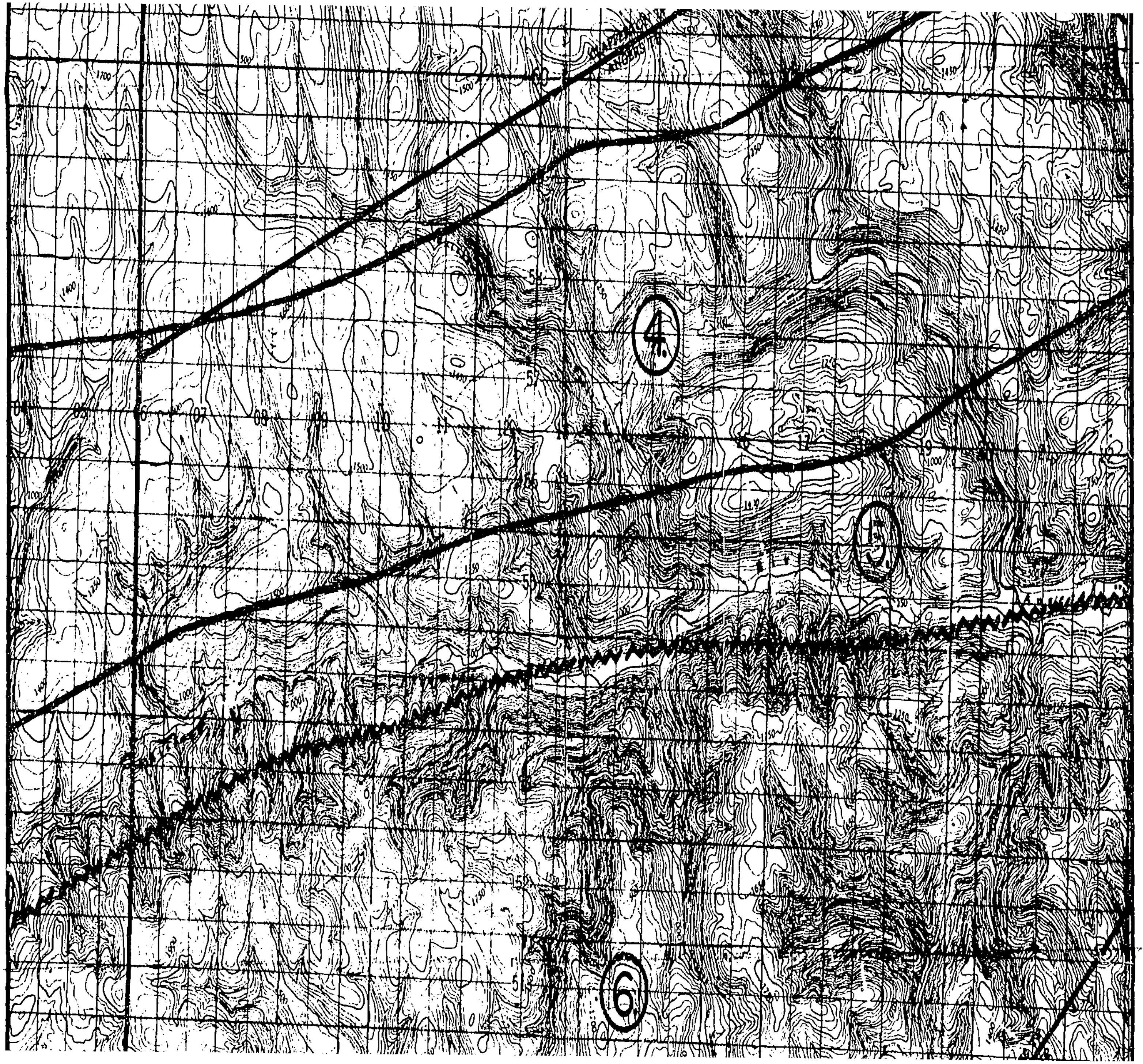

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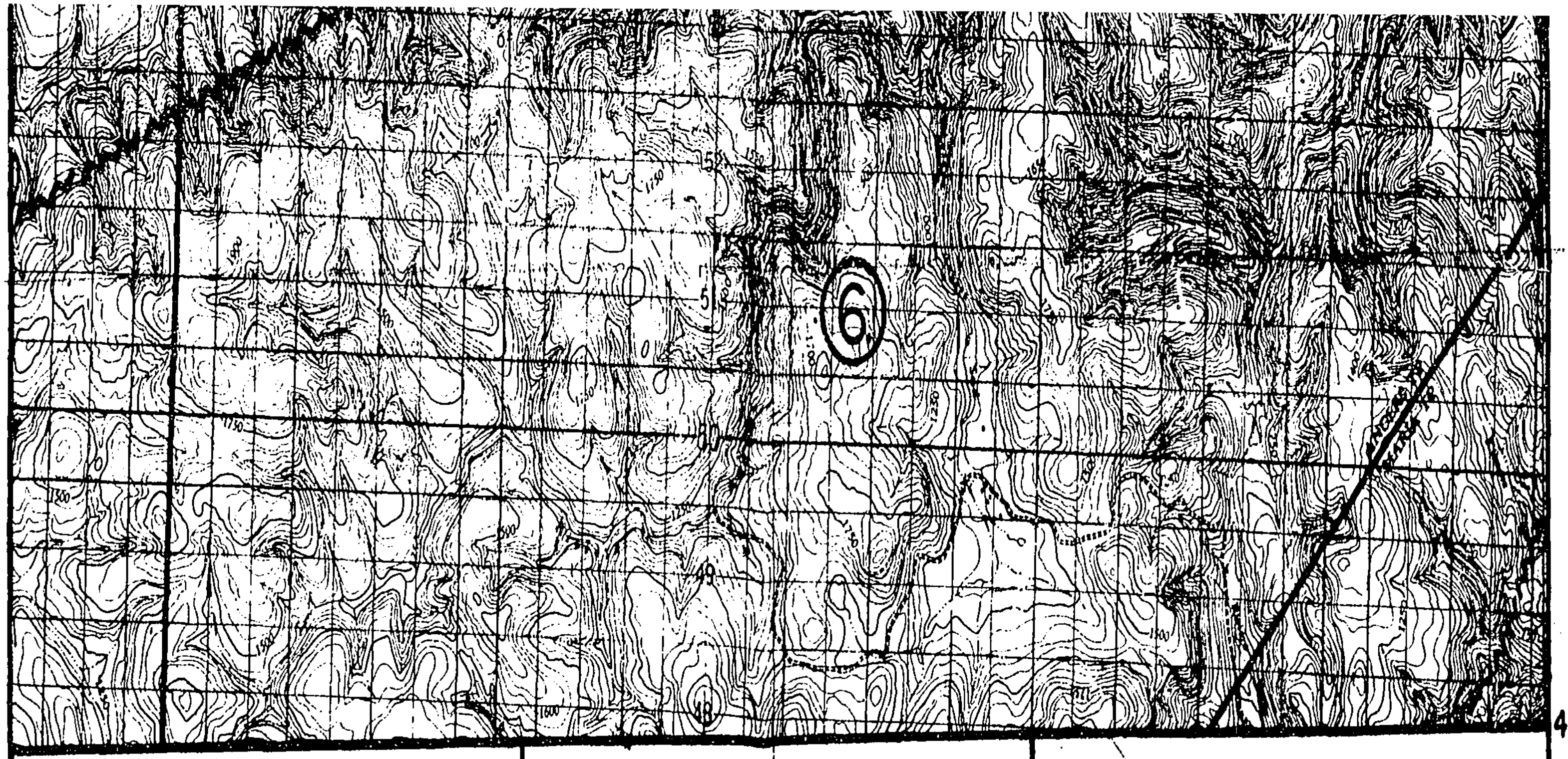


① **York River Formation:** (Middle Devonian)
Greenish grey, medium to fine grained feldspathic sandstone with minor interbedded greenish grey, silty shale.

② **Jonathan Formation:** (Upper Silurian)
Medium to fine grained amygdaloidal to porphyritic, generally ophitic andesite, interbedded with thin zones of hard, acidic tuffs; minor siltstones.

③ **Fortin Group:** (Lower Devonian)
Undifferentiated dark grey slate and argillaceous limestone; minor feldspathic sandstone and conglomerate.

④ **Mont Alexandre Group:** (Upper and Middle Silurian)
Undifferentiated volcanic rocks (basic to intermediate lavas), and grey siltstones; minor limestone, conglomerate, tuffs and agglomerate.

⑤ **Matapedia Group:** (Ordovician and Lower Silurian)
Light to medium grey limestone, and grey. calcareous shale.

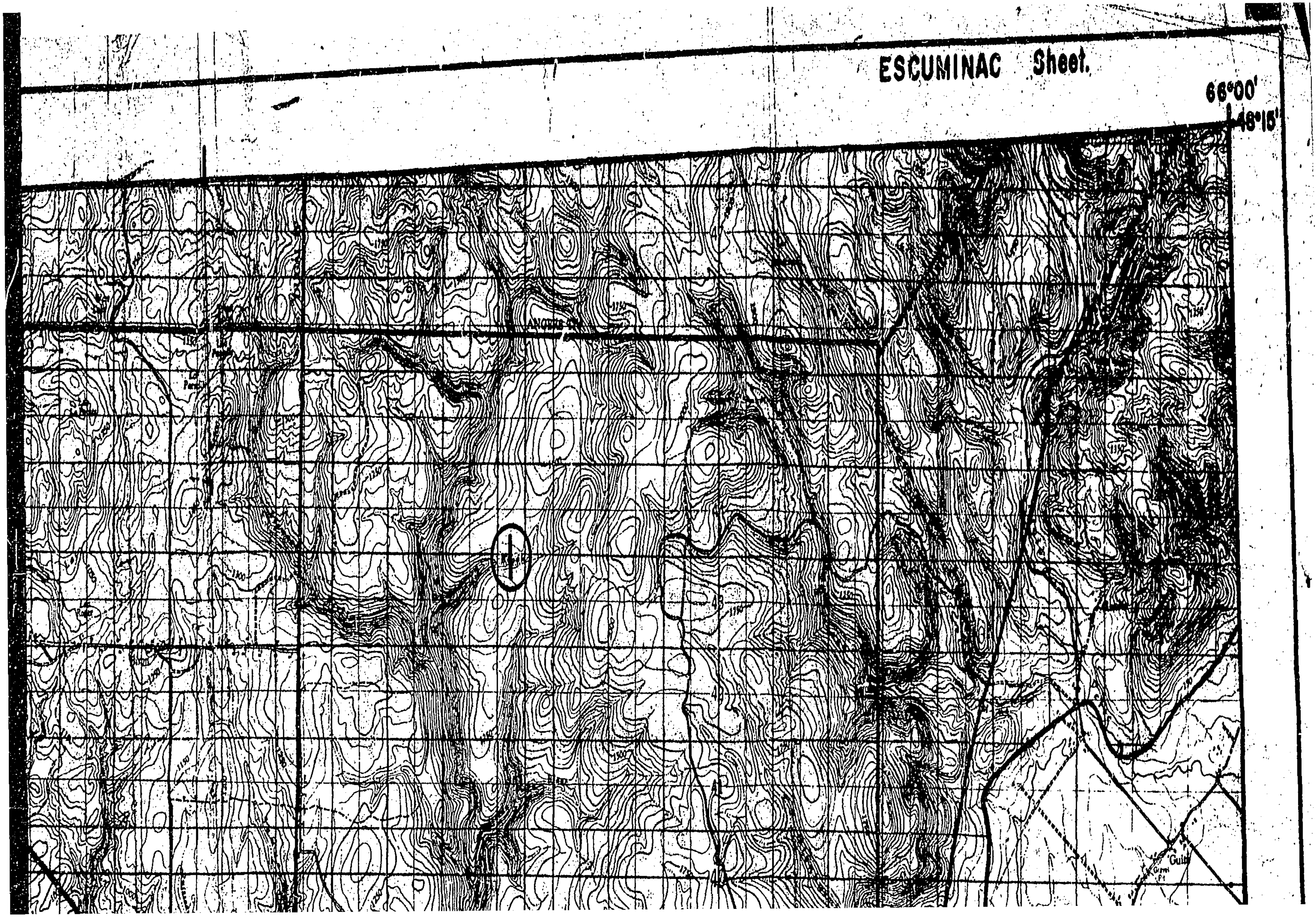
⑥ **Honorat Group:** (Ordovician)
Grey, fine to medium grained sandstone and mudstone; minor conglomerate and grey limestone.

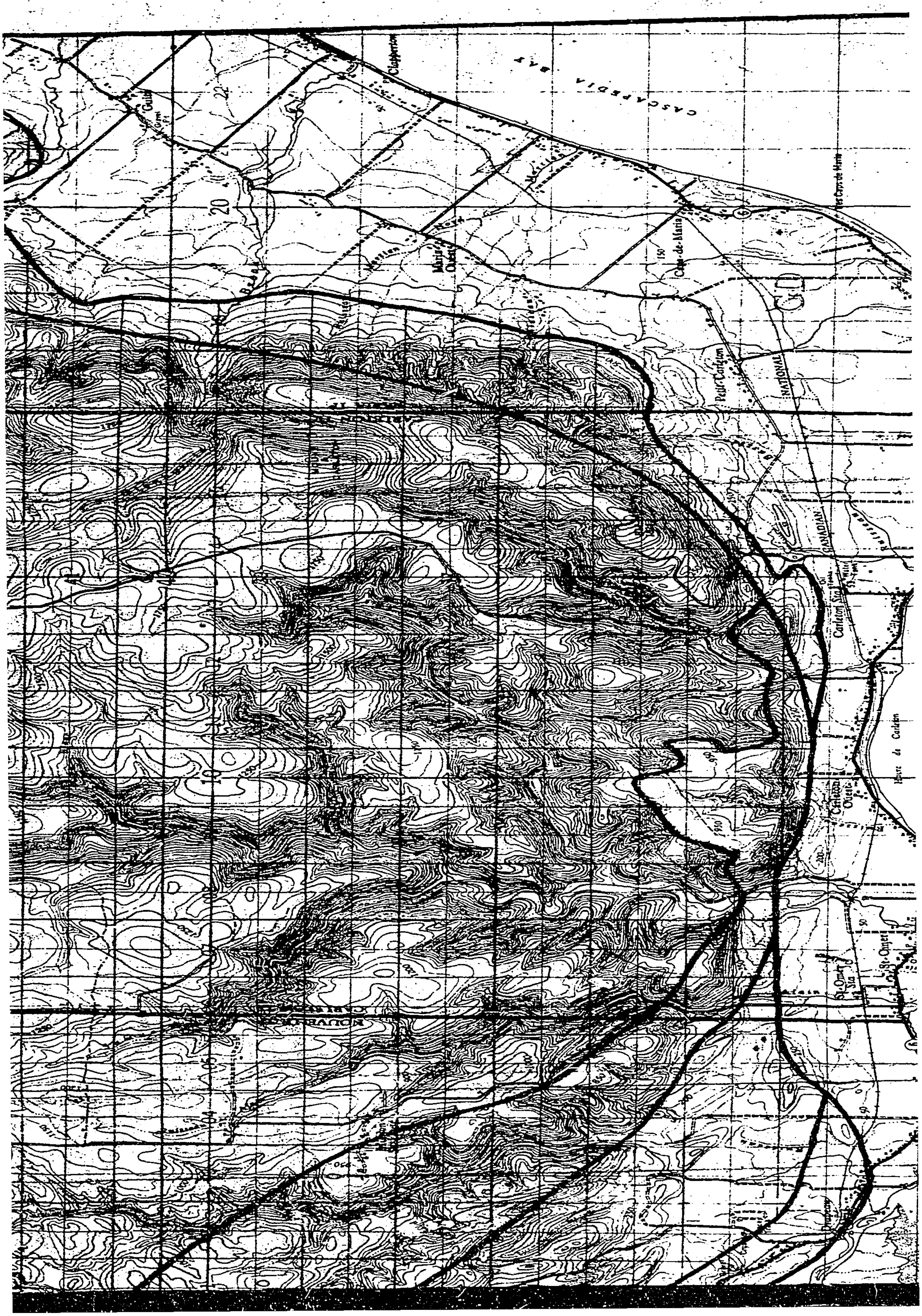
Topographic base: Canadian National Topographic System Sheet 22-B-8 (East).
Geology: Quebec Dept. Natural Resources Interim Report (Geological), Manuscript (by W.B.Skidmore, 1960).

Note: Numbering of units has no age connotation.

MAP NO: 4.

J.J.Naudsepp (1967)-Lithology and altitude in Gaspé Peninsula.


ESCUMINAC Sheet.
66°00'
48°15'



CASCAPEDIA BAY
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Pointe Crayes de Maria
Maria Ouest
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Carleton Sta
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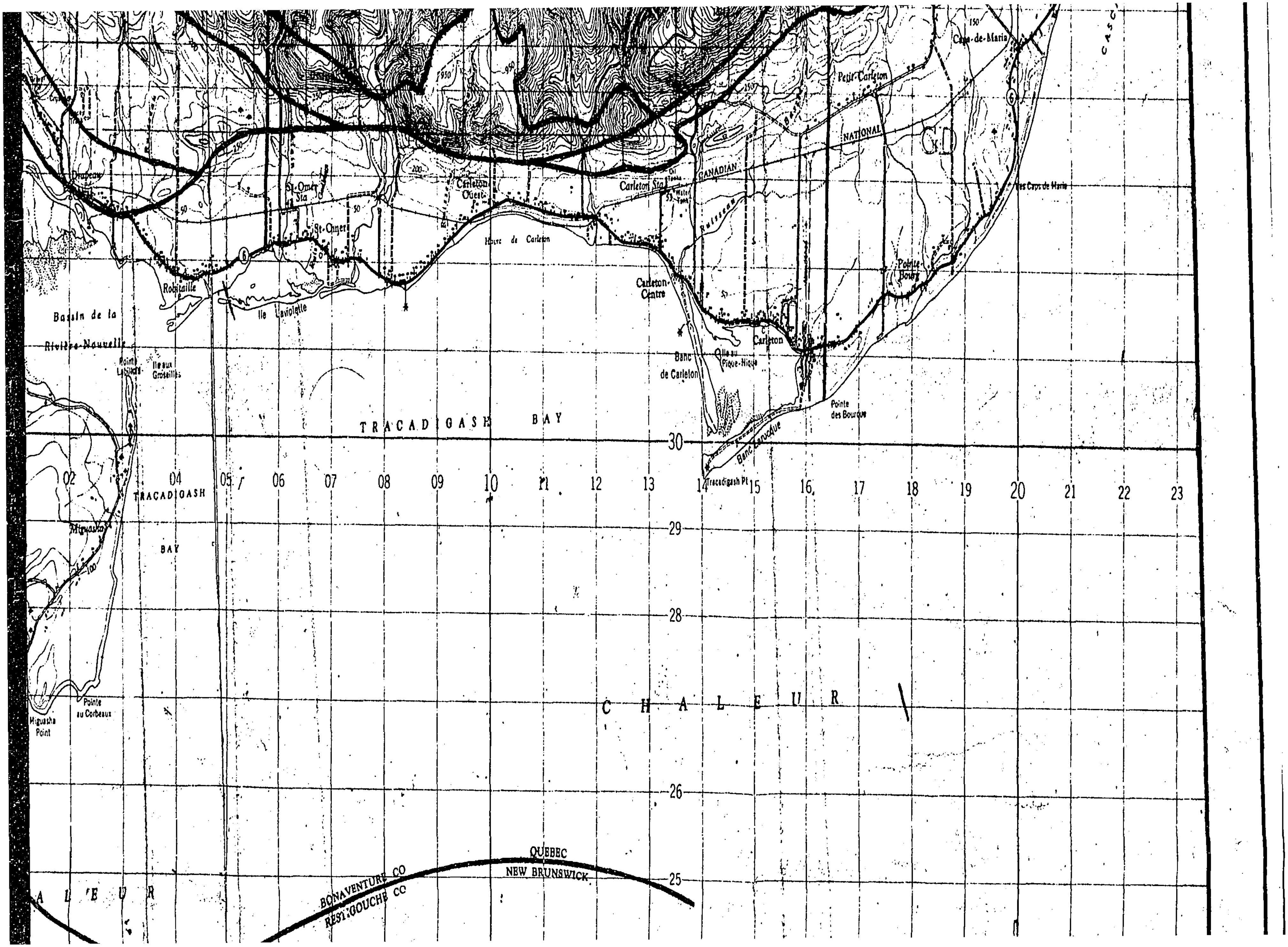
Cap-de-Maria
Petit-Carleton
NATIONAL
CANADIAN
Drapeau
St-Omer Sta
St-Omer
Carleton Ouest
Carleton Sta
Ruisseau
Havre de Carleton
Robitaille
Ile Laviolette
Carleton-Centre
Carleton
Banc de Carleton
Ile au Pique-Nique
Pointe Bourg
Pointe des Bourque
Les Caps de Maria
Bassin de la Rivière-Nouvelle
Pointe Labillois
Ile aux Groseilles
TRACADIGASH BAY
Tracadigash Pt
Banc Larocque
TRACADIGASH BAY
Miguasha
Pointe au Corbeaux
Miguasha Point
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ALEUR
QUEBEC
NEW BRUNSWICK
BONAVENTURE CO
RESTIGOUCHE CO
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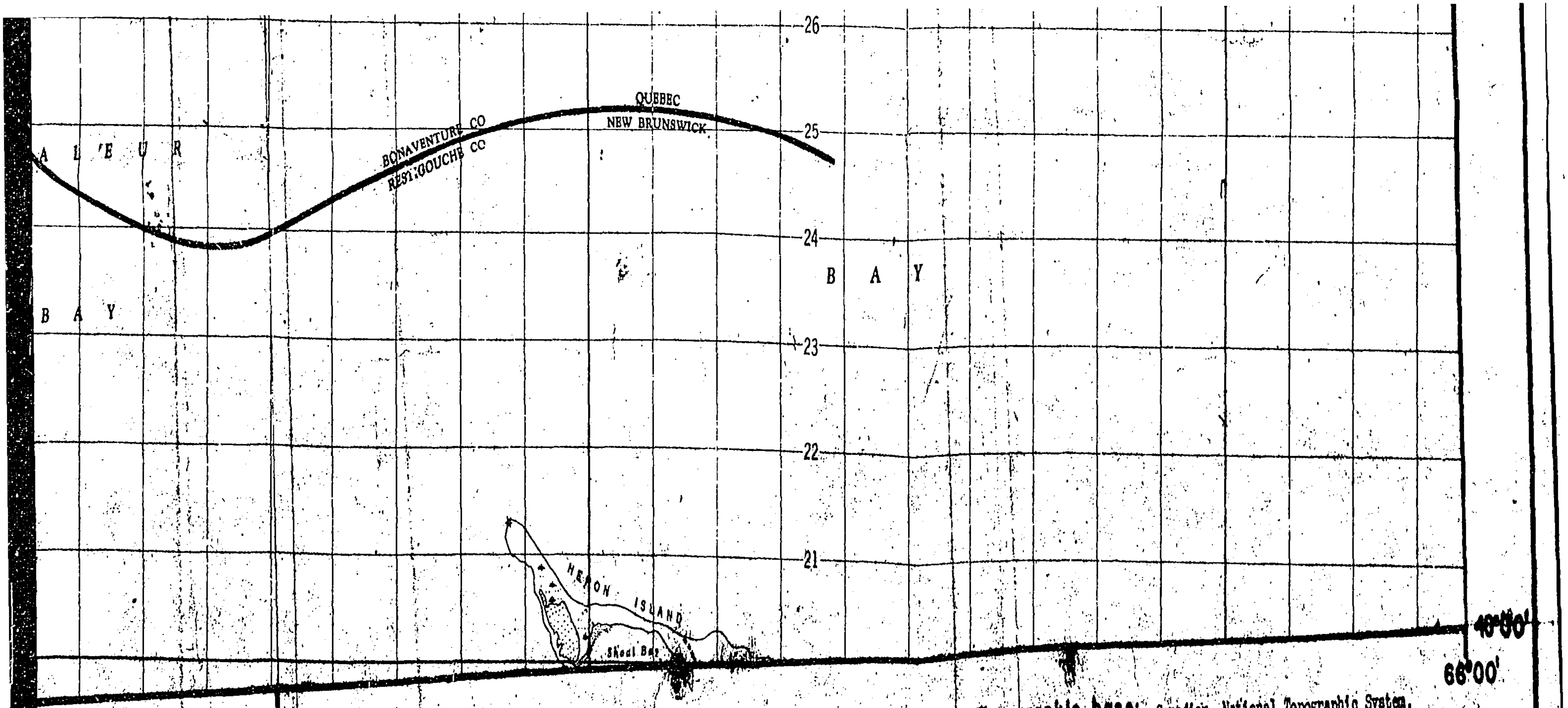


and Lower Silurian)
estone, argillaceous limestone,
.

③

Restigouche Group: (Silurian and-or Devonian)
Undifferentiated calcareous mudstones, siltstones,
and basic to intermediate lavas and agglomerate.

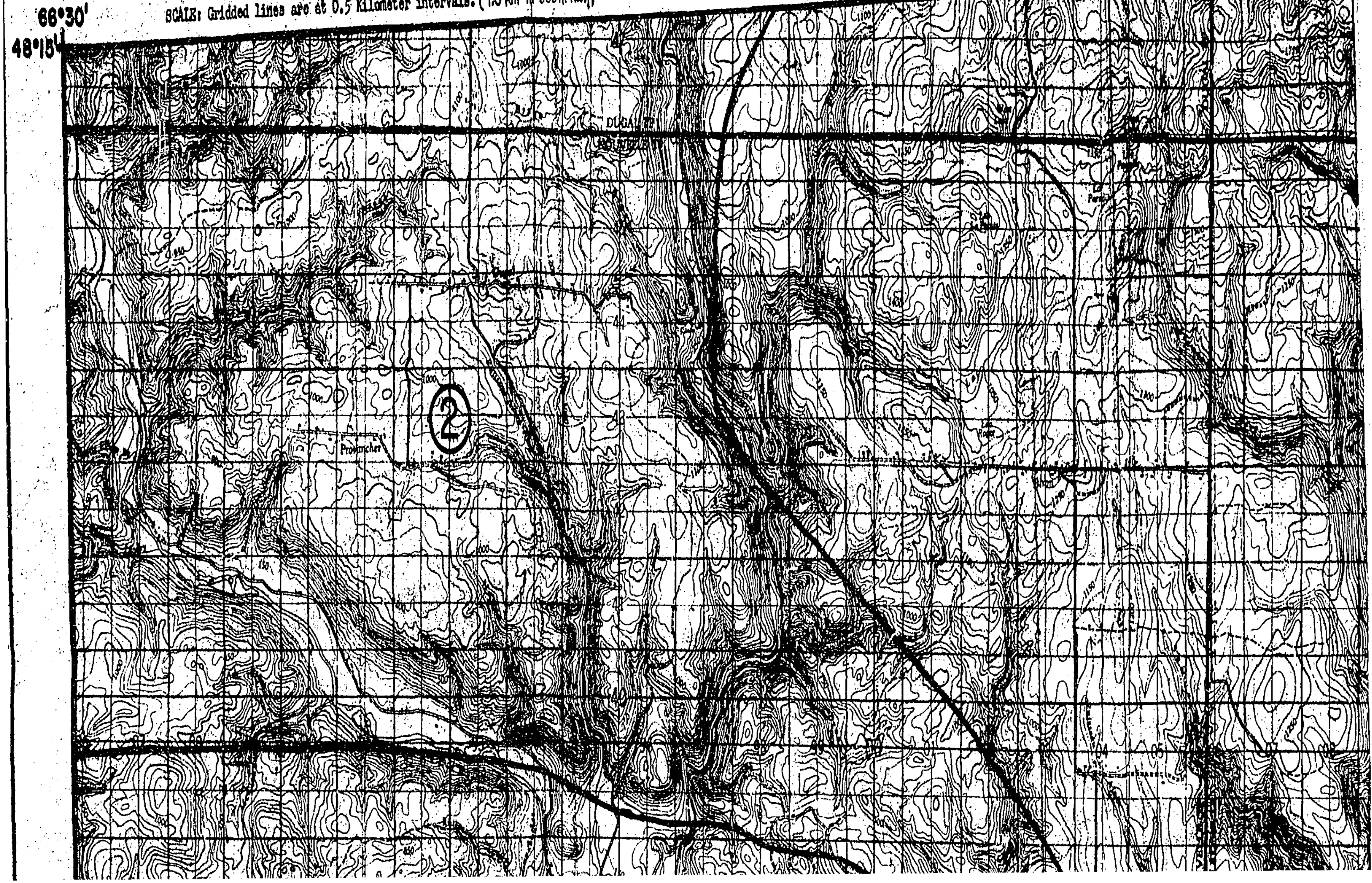
Topographic base: Canadian National Topographic System,
Sheet 22-B-1.

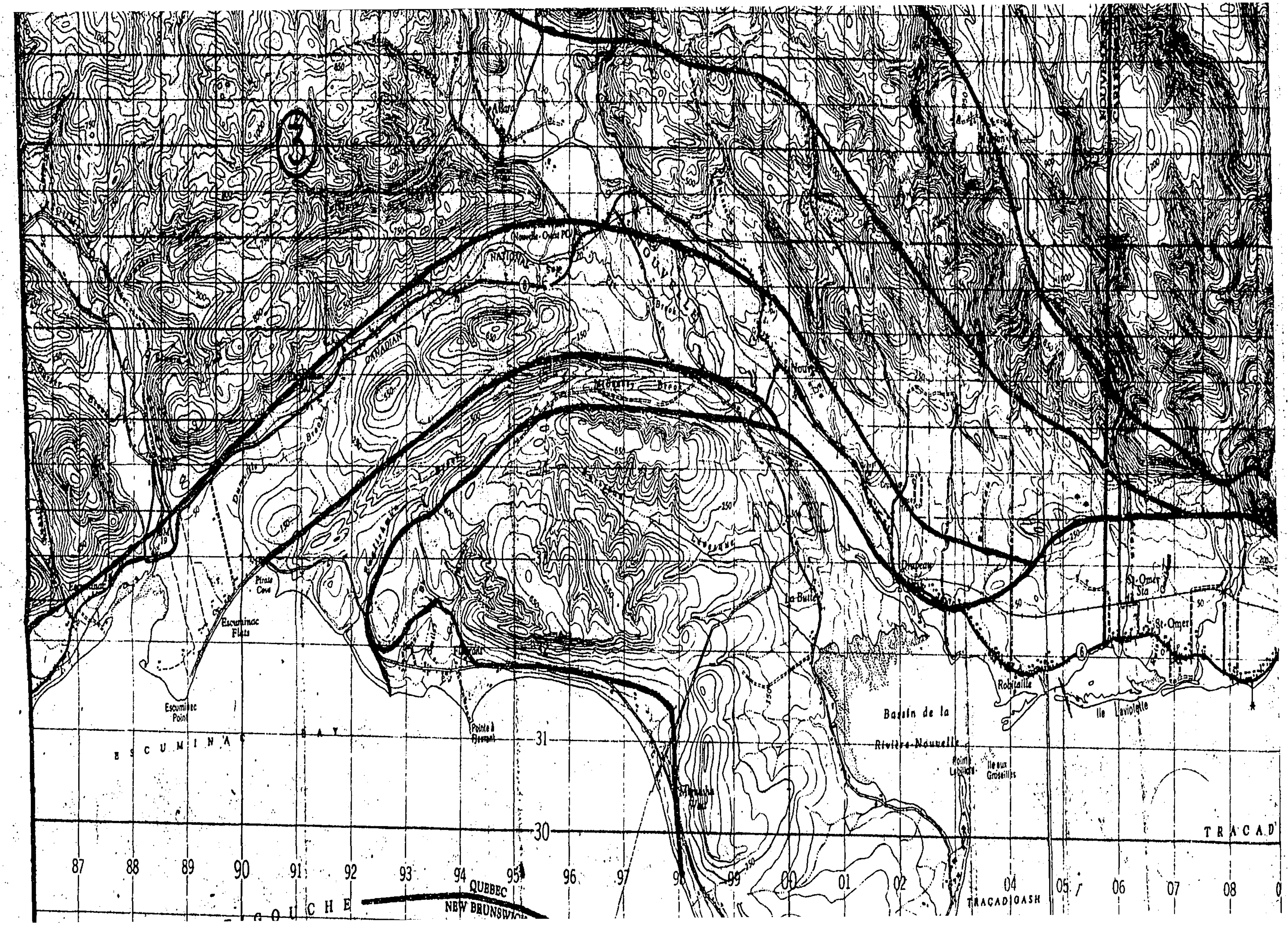
Geology: Quebec Dept. Natural Resources, Interim Report (Geological),
Manuscript, (by W.B.Skidmore, 1960).

MAP NO. 5.

CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals. (1.0 Km in south half)

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Escuminac Point
Escuminac Flats
Pirate Cove
E S C U M I N A C
B A Y
Pointe à Fleurant
Bassin de la
Rivière-Nouvelle
Point Leblanc
Ileaux Groseilles
Robitaille
Ile Laviolette
St-Omer Sta
St-Omer
La Butte
Drapeau
Nouvelle-Ouest P.O.
NATIONAL
CANADIAN
TRACADIGASH
QUEBEC
NEW BRUNSWICK
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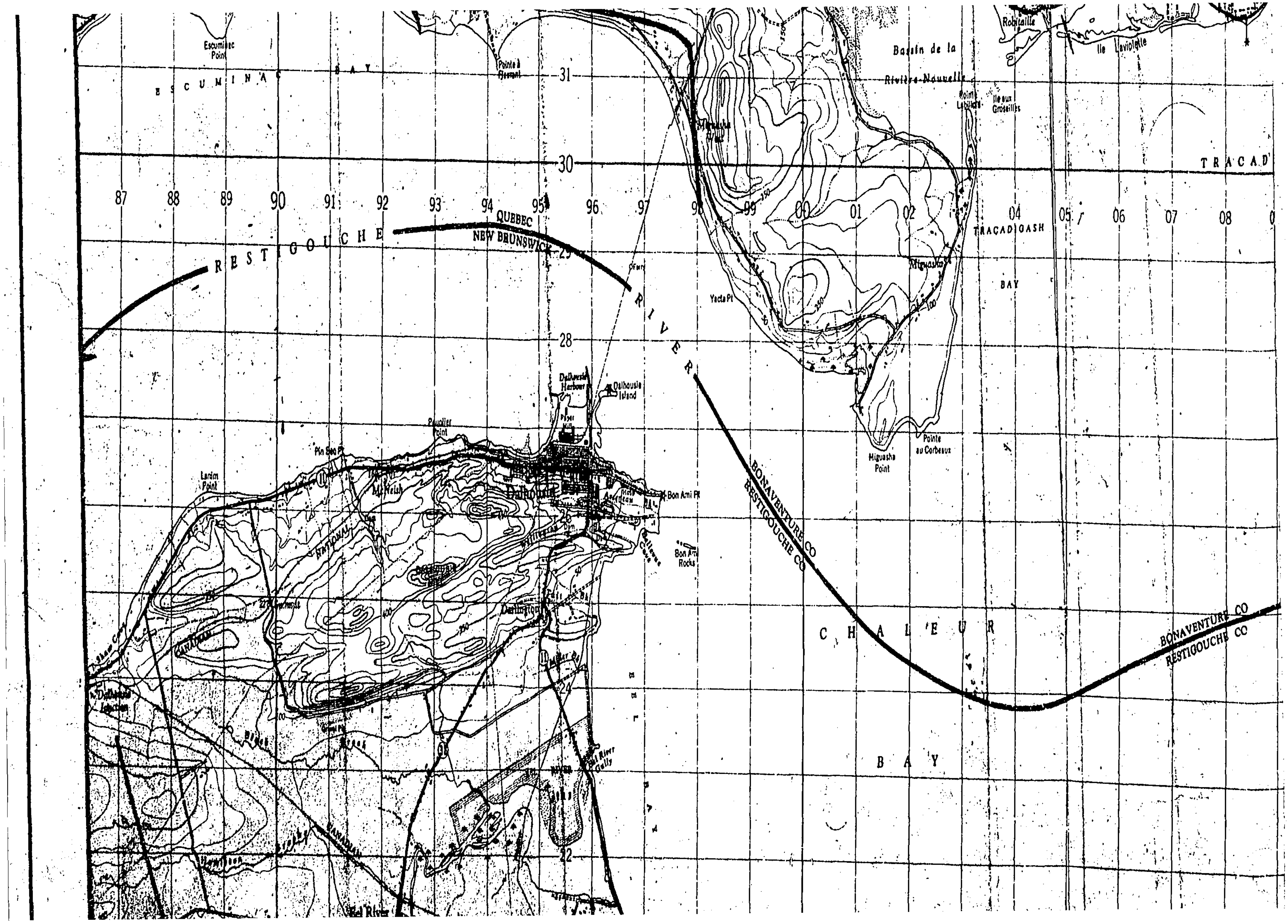
ESCUMINAC BAY
Escuminac Point
Pointe à Fleurant
Bassin de la Rivière-Nouvelle
Robitaille
Ile Laviolette
Point Labillois
Ileaux Groseilles
TRACAD
TRACADIGASH
BAY
Miguasha
Yacta Pt
Pointe au Corbeaux
Miguasha Point
RESTIGOUCHE RIVER
QUEBEC
NEW BRUNSWICK
Dalhousie Harbour
Dalhousie Island
Paper Mill
Pouilier Point
Pin Sec Pt
Larim Point
Dalhousie
Bon Ami Pt
Bon Ami Rocks
Bellevue Cove
Dalhousie Junction
Eel River
Eel River Gully
CHALEUR BAY
BONAVENTURE CO
RESTIGOUCHE CO
NATIONAL
CANADIAN
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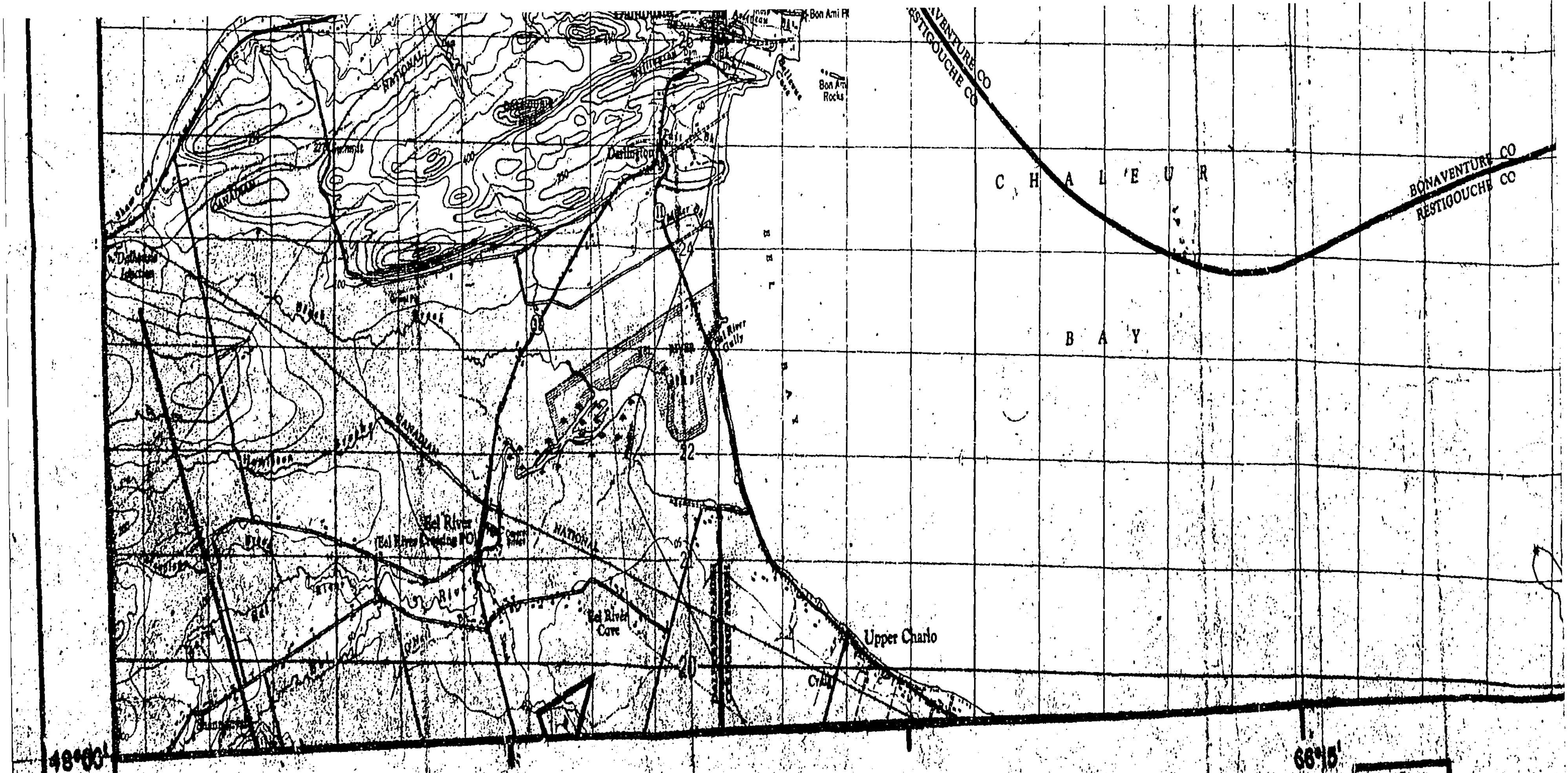
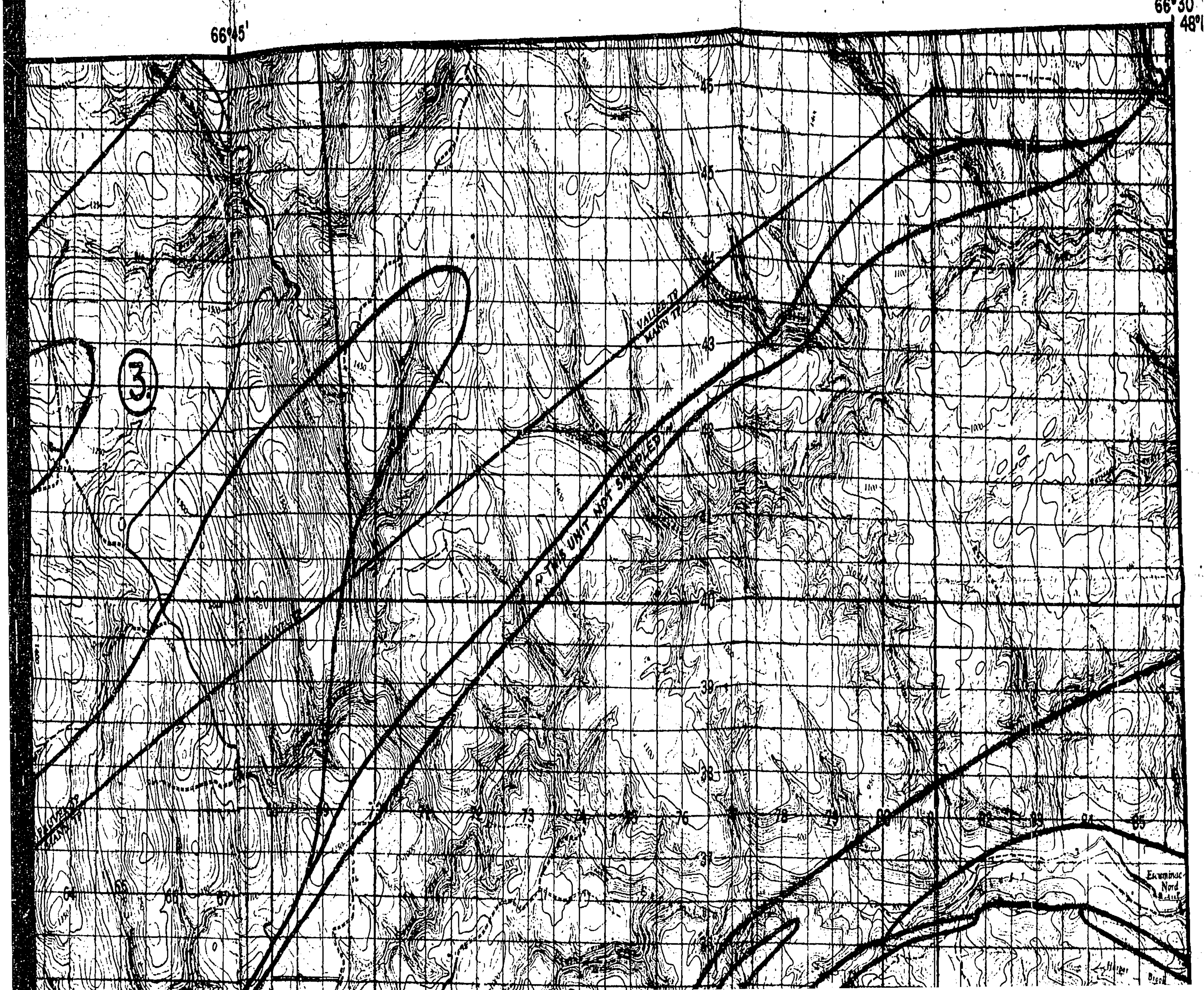


① **Honorat Group:** (Ordovician)
Grey, fine to medium grained sandstone and mudstone,
minor conglomerate and grey limestone.

② **Matapedia Group:** (Ordovician and Lower Silurian)
Light to medium grey limestone, argillaceous limestone,
and grey calcareous shale.

③ **Restigouche**
Und
and

OAK BAY Sheet.

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MANN FAULT
Alverne
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ESCUMINAC
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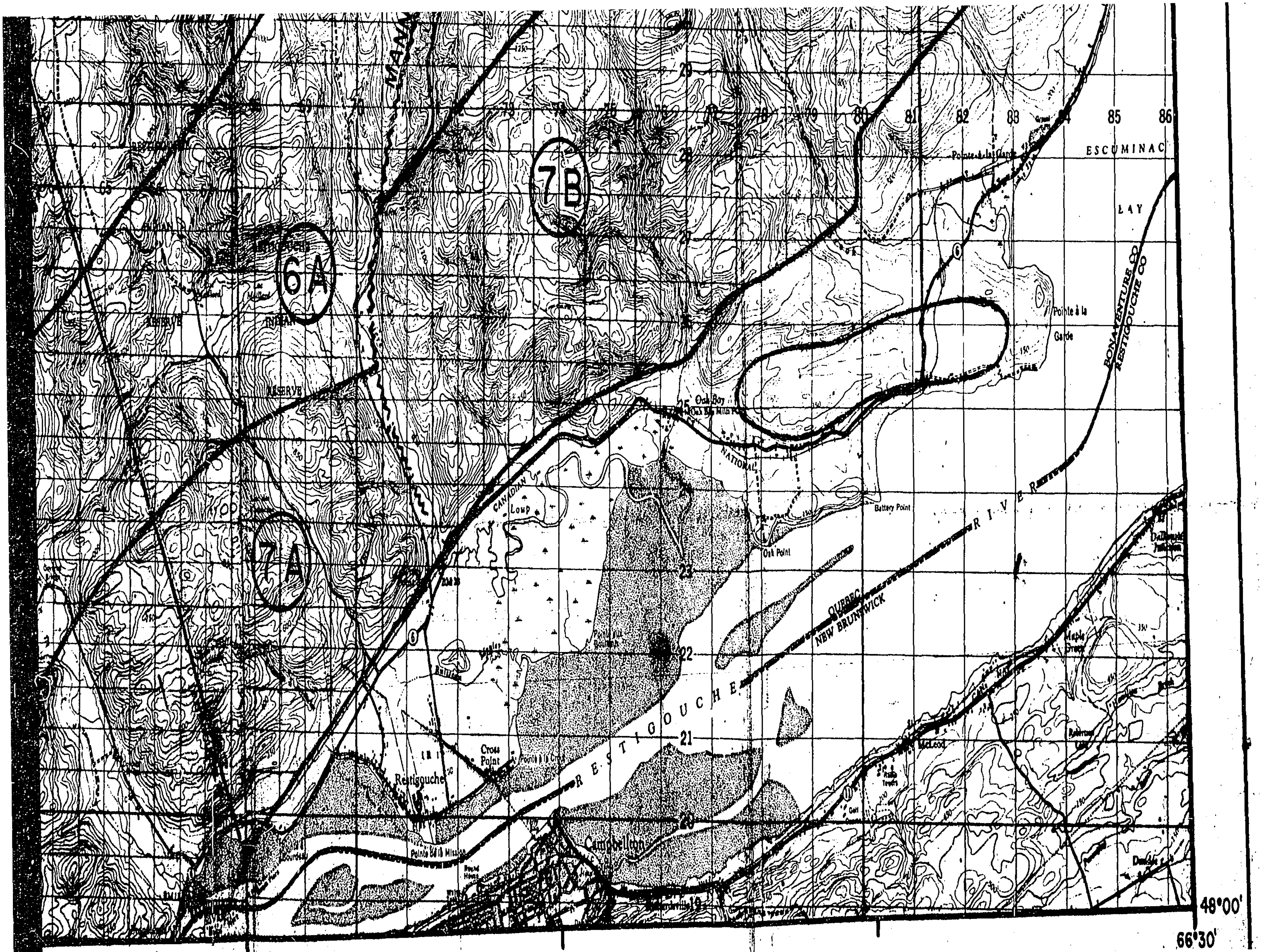


of units has no age connotation.

of units has no age connotation.

(Lower Devonian)
careous);
llaceous to silty limestone.

Silurian)
tone , argillaceous to silty

calcite veining.

⑥ **Restigouche Group:** (Silurian and-or Devonian)
Grey, red, grey-green calcareous mudstone , quartzose sandstone ; minor argillaceous, silty to sandy limestone , intraformational conglomerate, limestone reefs.

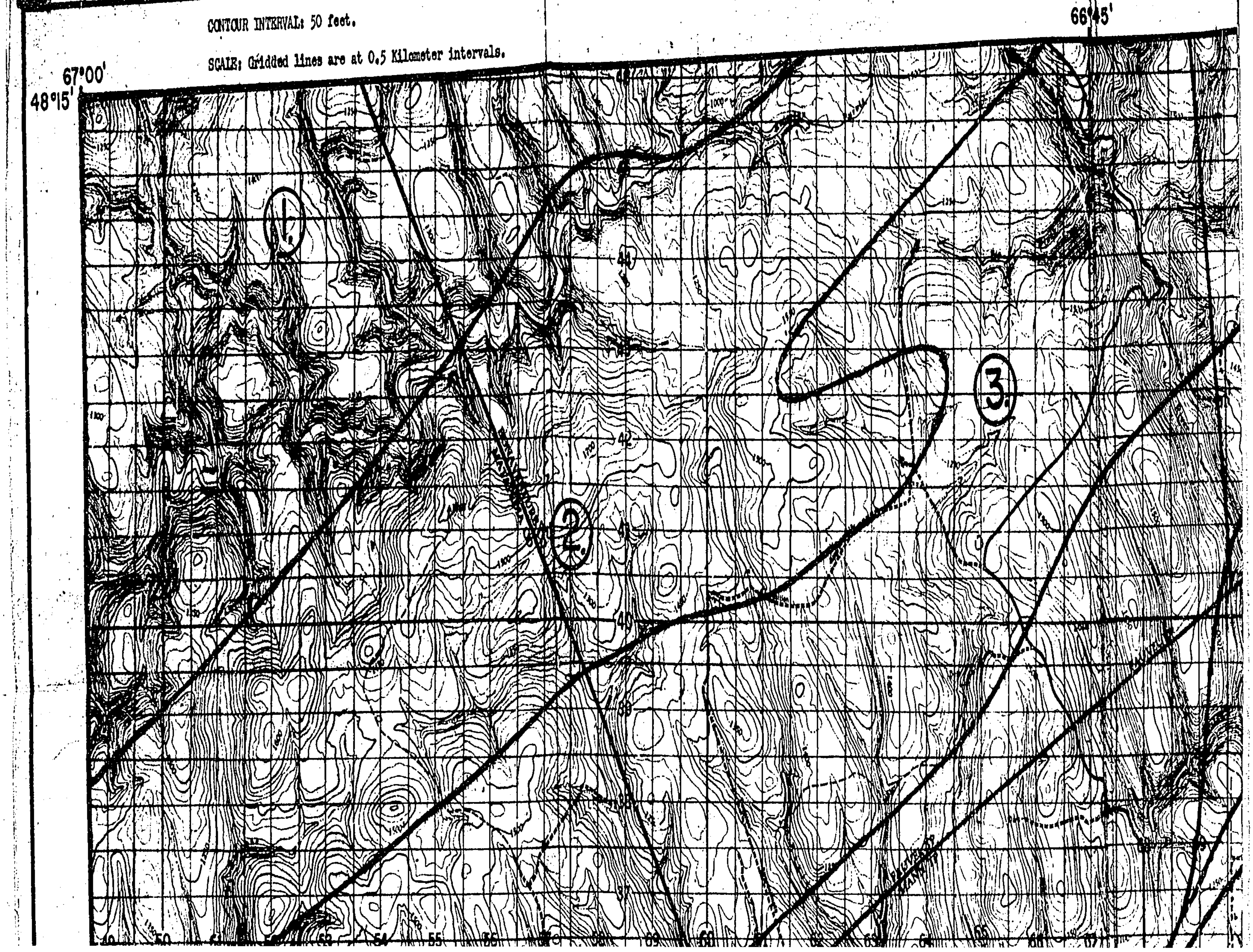
⑦ **Restigouche Group:** (Silurian and-or Devonian)
Black, dark grey, dark green basic and intermediate lava flows devoid of pillows; with intercalated tuffs and agglomerates.

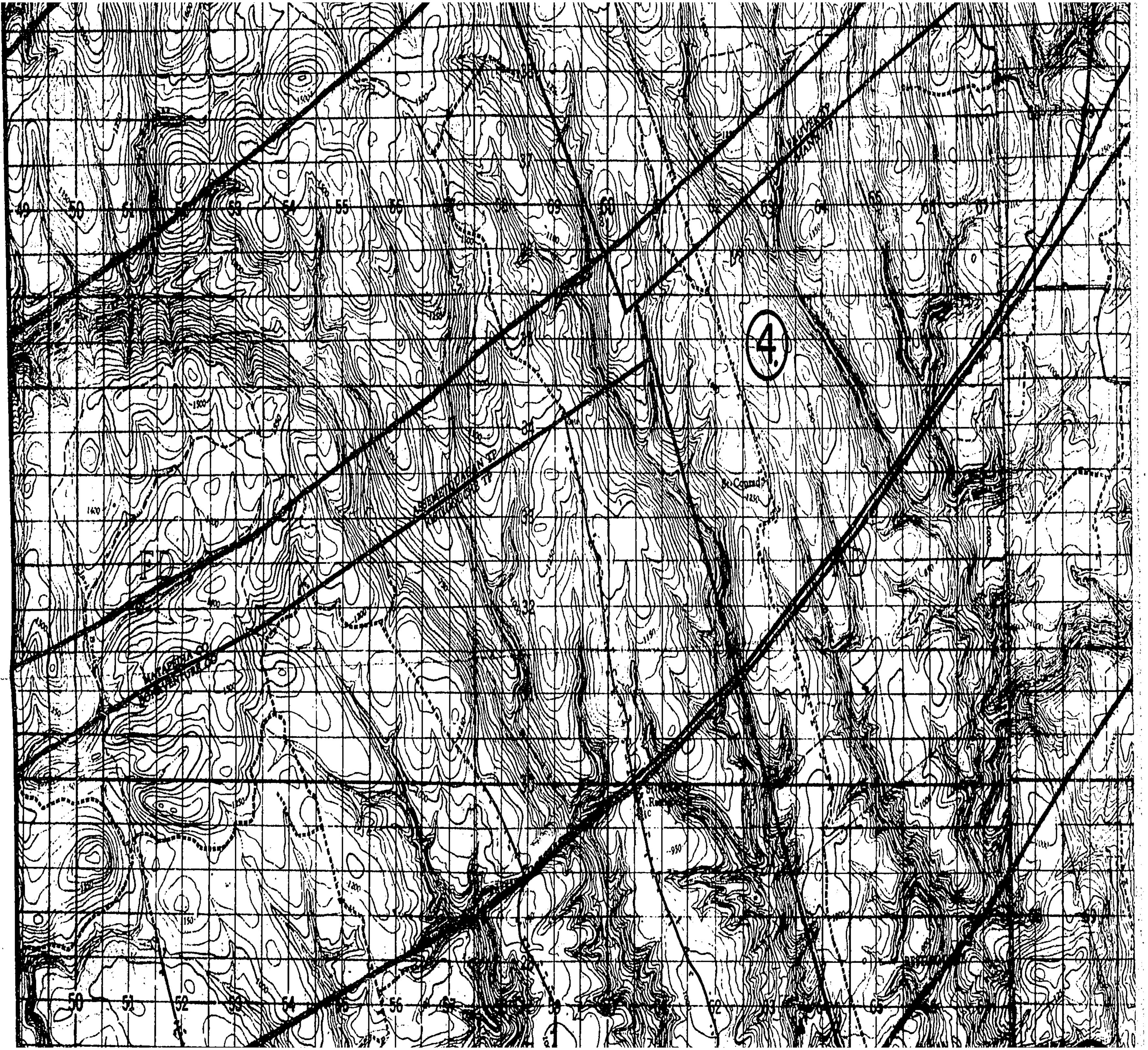
Topographic base: National Topographic System Sheet 22-B-2.
Geology: Quebec Dept. Mines (Natural Resources) Preliminary Report no. 375, (by J.Beland-1958).

MAP NO: 6.

CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.





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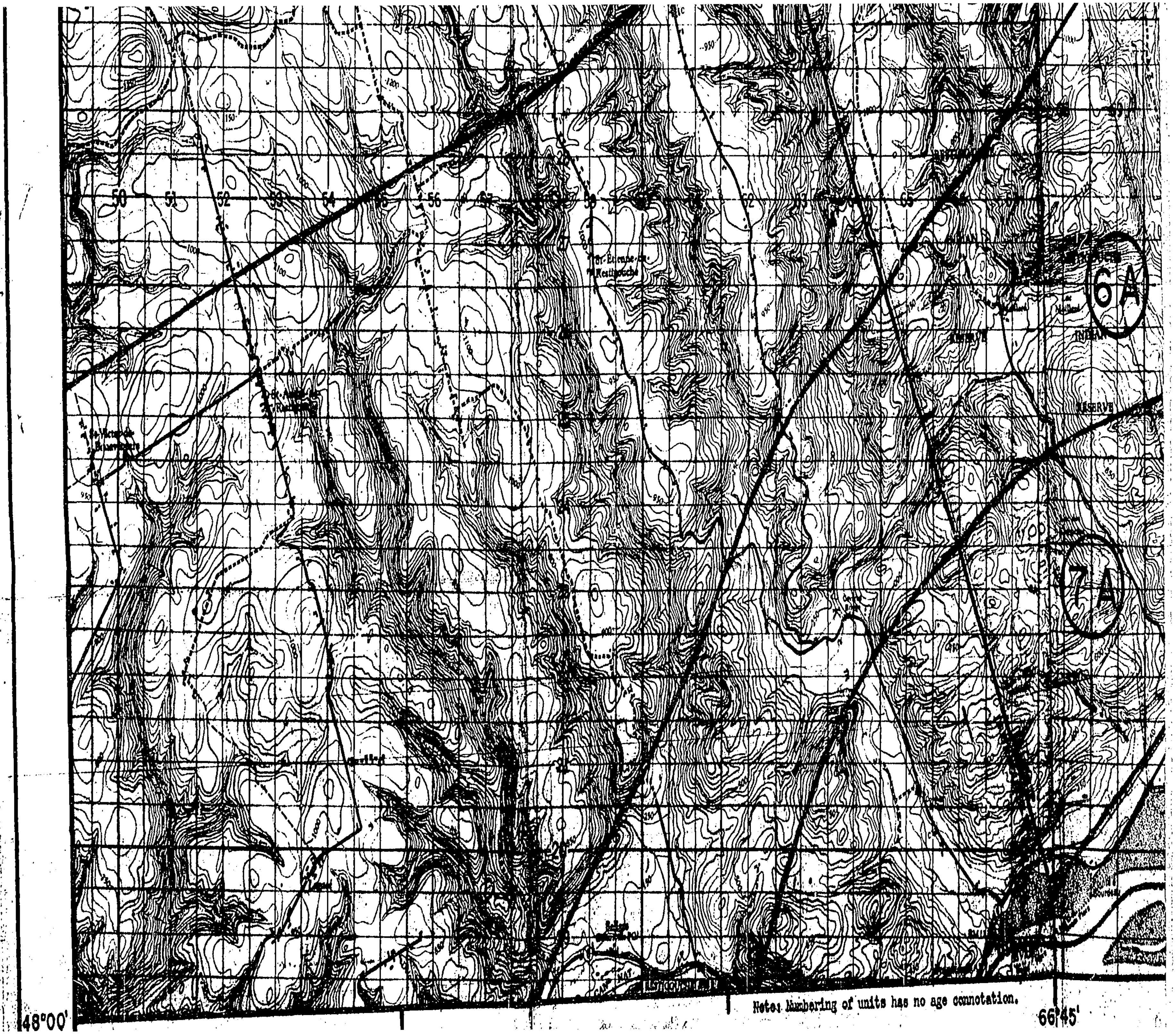
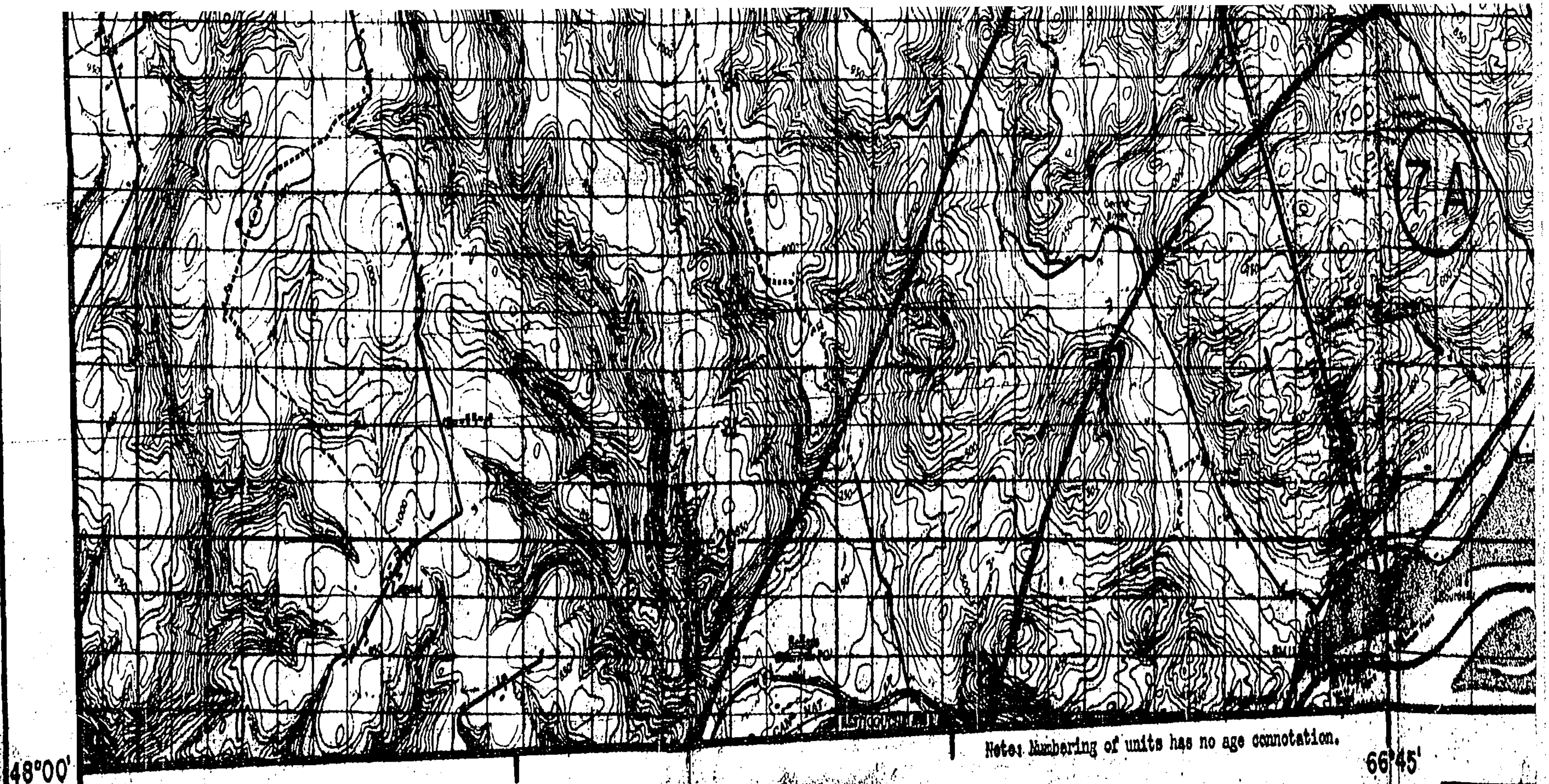


Note: Numbering of units has no age connotation.



Note: Numbering of units has no age connotation.

①&③	<u>Shaly facies of the Fortin Group:</u> . (Lower Devonian) Dark grey shale (locally calcareous); minor grey siltstone and argillaceous to silty limestone.
②	<u>Sandy facies of the Fortin Group:</u> (Lower Devonian) Grey sandstone (locally calcareous); minor grits, grey siltstone and shale.
④	<u>Silty facies of the Fortin Group:</u> . (Lower Devonian) Dark grey siltstone (locally calcareous); minor dark grey shale and argillaceous to silty limestone.
⑤	<u>Matapedia Group:</u> . (Ordovician and Silurian) Light to dark grey, compact limestone, argillaceous to silty limestone, grey calcareous shale; minor calcarenite; widespread calcite veining.
⑥	
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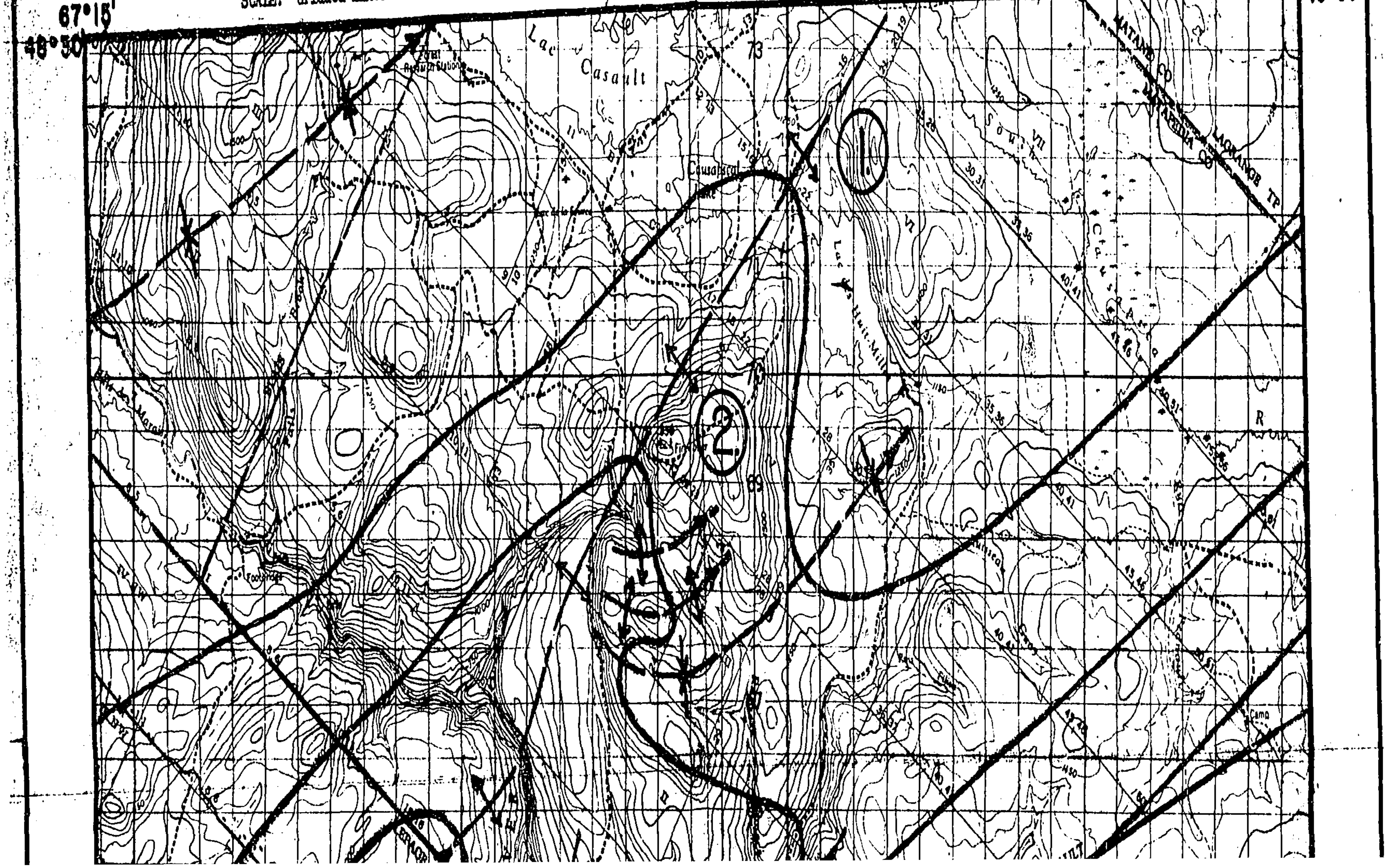
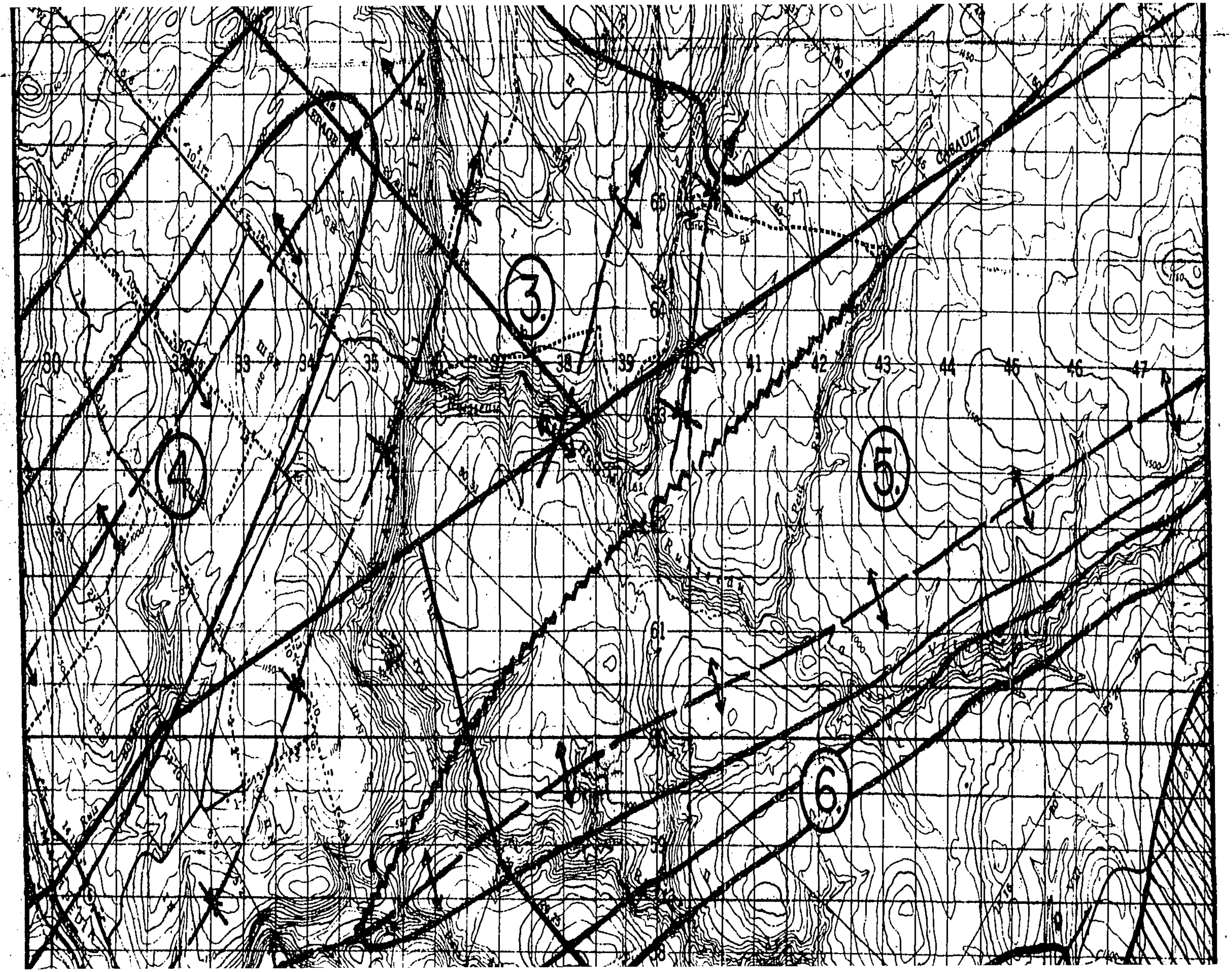
CAUSAPSCAL E/2 Sheet.

CONTOUR INTERVAL: 50 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.

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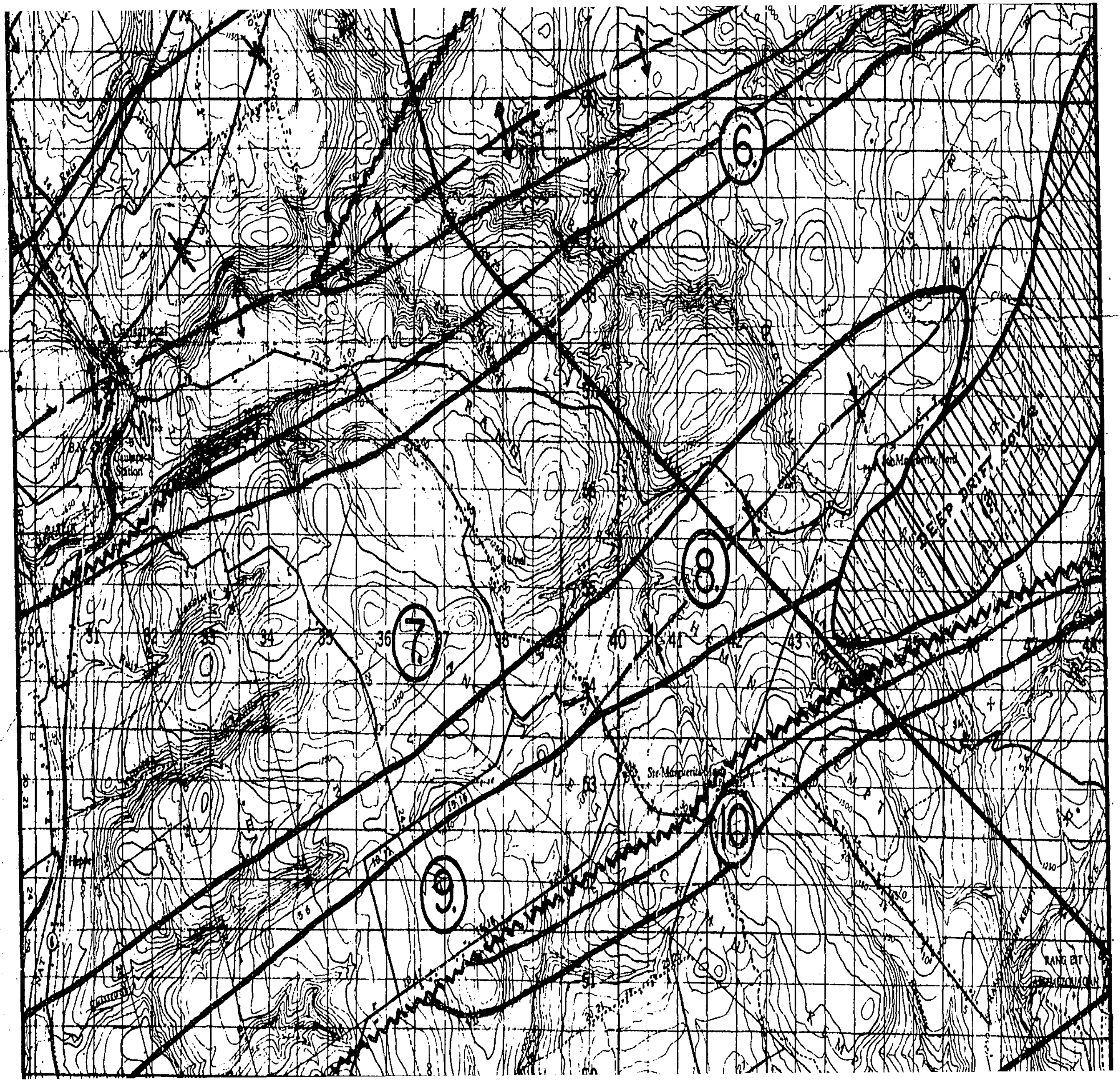

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DEEP DRIFT COVER
Ste-Marguerite
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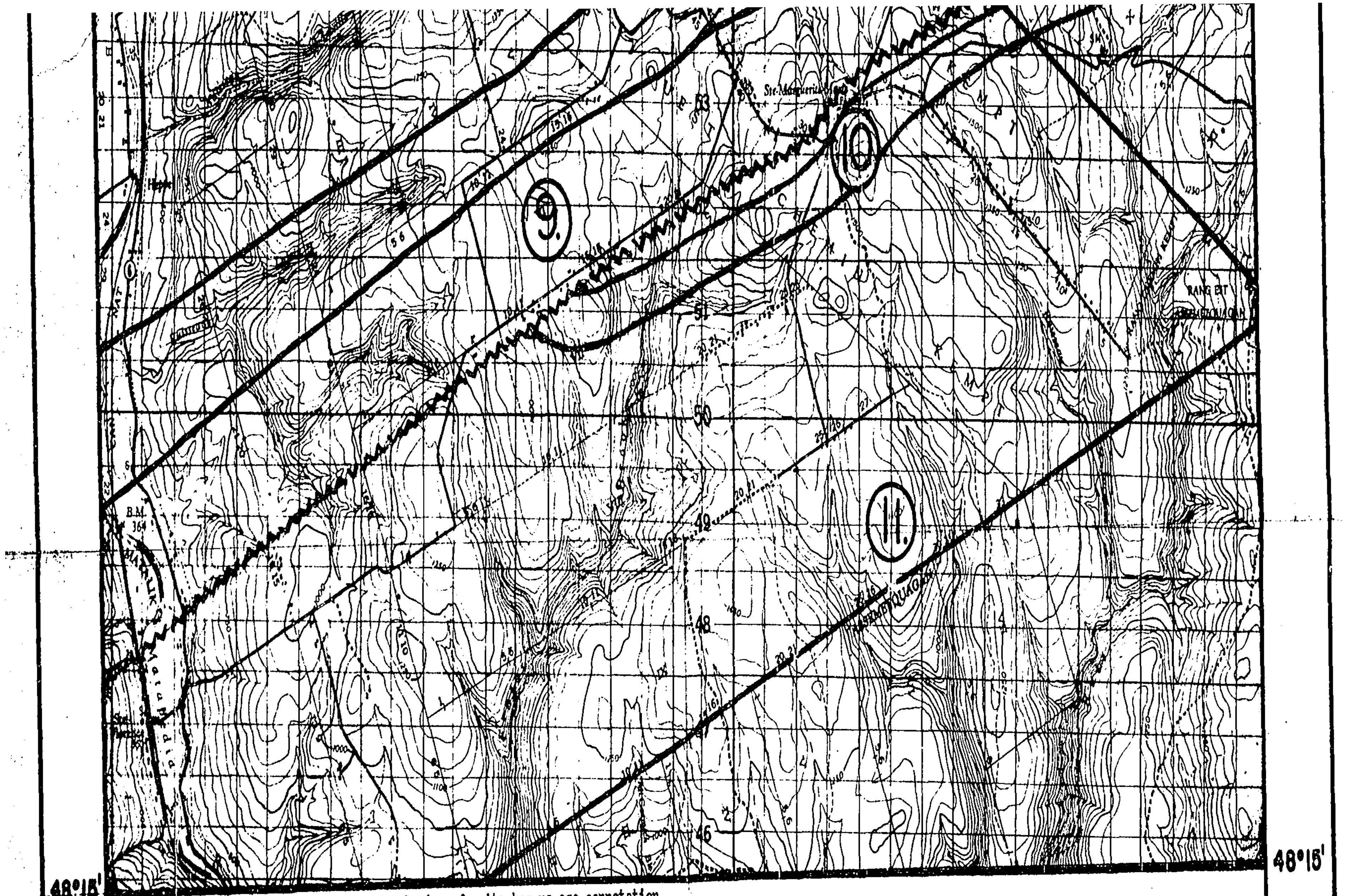


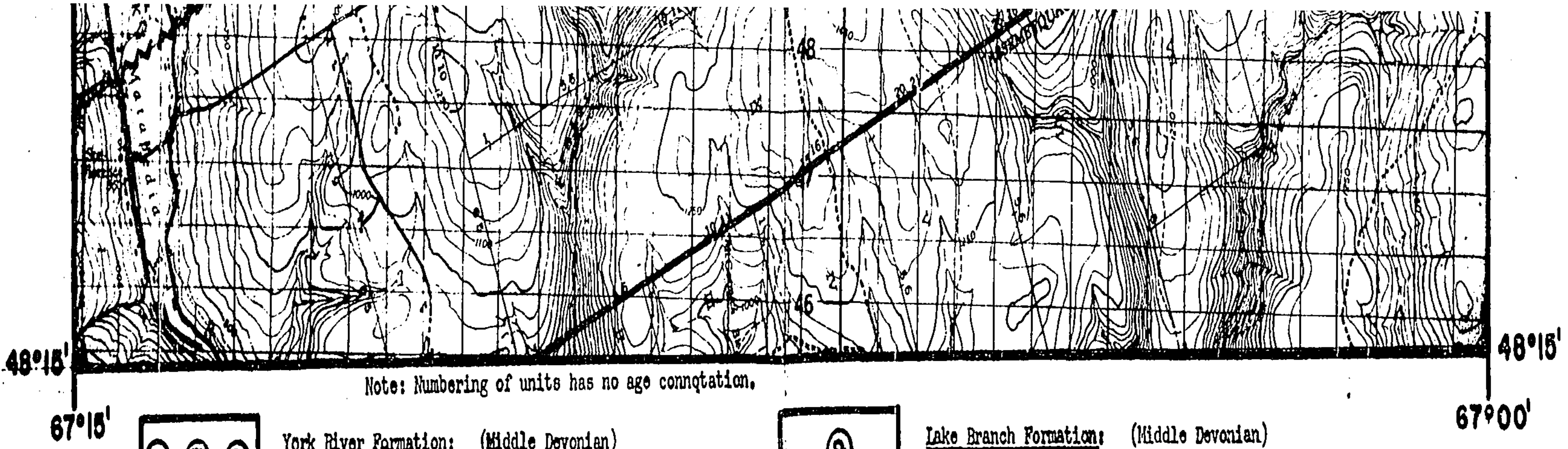
Note: Numbering of units has no age connqtation.

①&⑦&⑨ **York River Formation:** (Middle Devonian)
Light medium grey, medium grained, slightly calcareous, feldspathic sandstone and grey calcareous siltstone.

⑧ **Lake Branch Formation:** (Middle Devonian)
Brown to reddish brown, fine grained sandstone and red siltstone.

②&⑥ **Grande Grève Formation:** (Lower Devonian)
Grey, calcareous siltstone and siliceous

⑩ **Ste. Marguerite Volcanics:** (Middle and-or Lower Devonian)
Dark green, fine grained, amygdaloidal andesite ; minor sheared volcanic breccia.



Note: Numbering of units has no age connqtation.

①&⑦&⑨ **York River Formation:** (Middle Devonian)
Light medium grey, medium grained, slightly calcareous, feldspathic sandstone and grey calcareous siltstone.

②&⑥ **Grande Grève Formation:** (Lower Devonian)
Grey, calcareous siltstone and siliceous limestone.

③ **Cap Bon Ami Formation:** (Lower Devonian)
Dark grey, argillaceous and silty limestone.

④&⑤ **St. Leon Formation:** (Upper Silurian)
Greenish grey, calcareous siltstone; minor greenish grey, medium and fine grained sandstone.

⑧ **Lake Branch Formation:** (Middle Devonian)
Brown to reddish brown, fine grained sandstone and red siltstone.

⑩ **Ste. Marguerite Volcanics:** (Middle and-or Lower Devonian)
Dark green, fine grained, amygdaloidal andesite ; minor sheared volcanic breccia.

Topographic base: Canadian National Topographic System, Sheet 22-B-6 (East).
Geology: Quebec Dept. Mines (Natural Resources), Preliminary Report no. 382, (by C.W.Stearn, 1959);
also: Manuscript, Quebec Dept. Mines (Natural Resources), Geological Report series.

⑪ **Fortin Group:** (Lower Devonian)
Dark to medium grey, micaceous, calcareous slate and phyllitic slate; minor intercalated beds of greywacke.

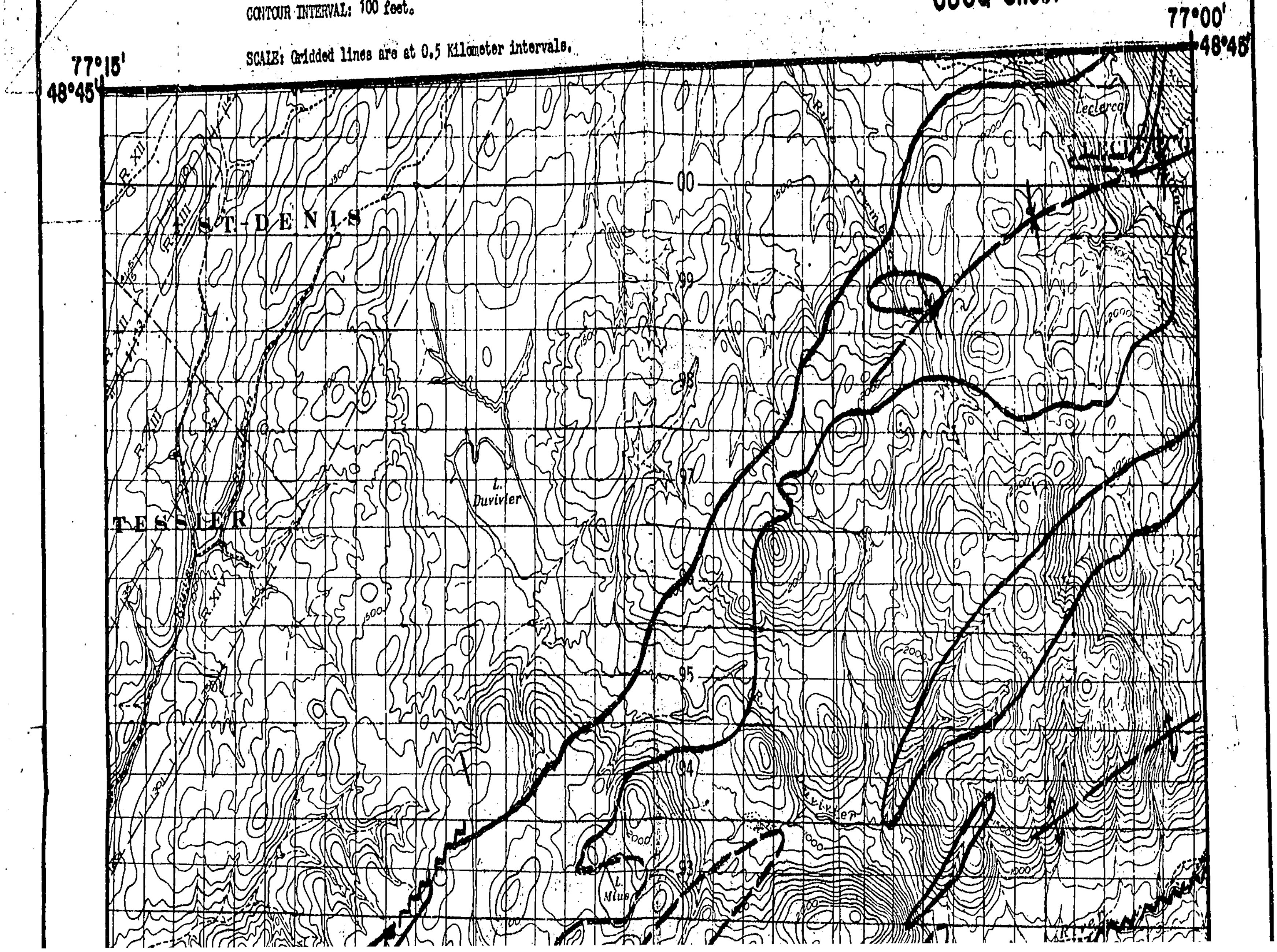
MAP NO: 7.

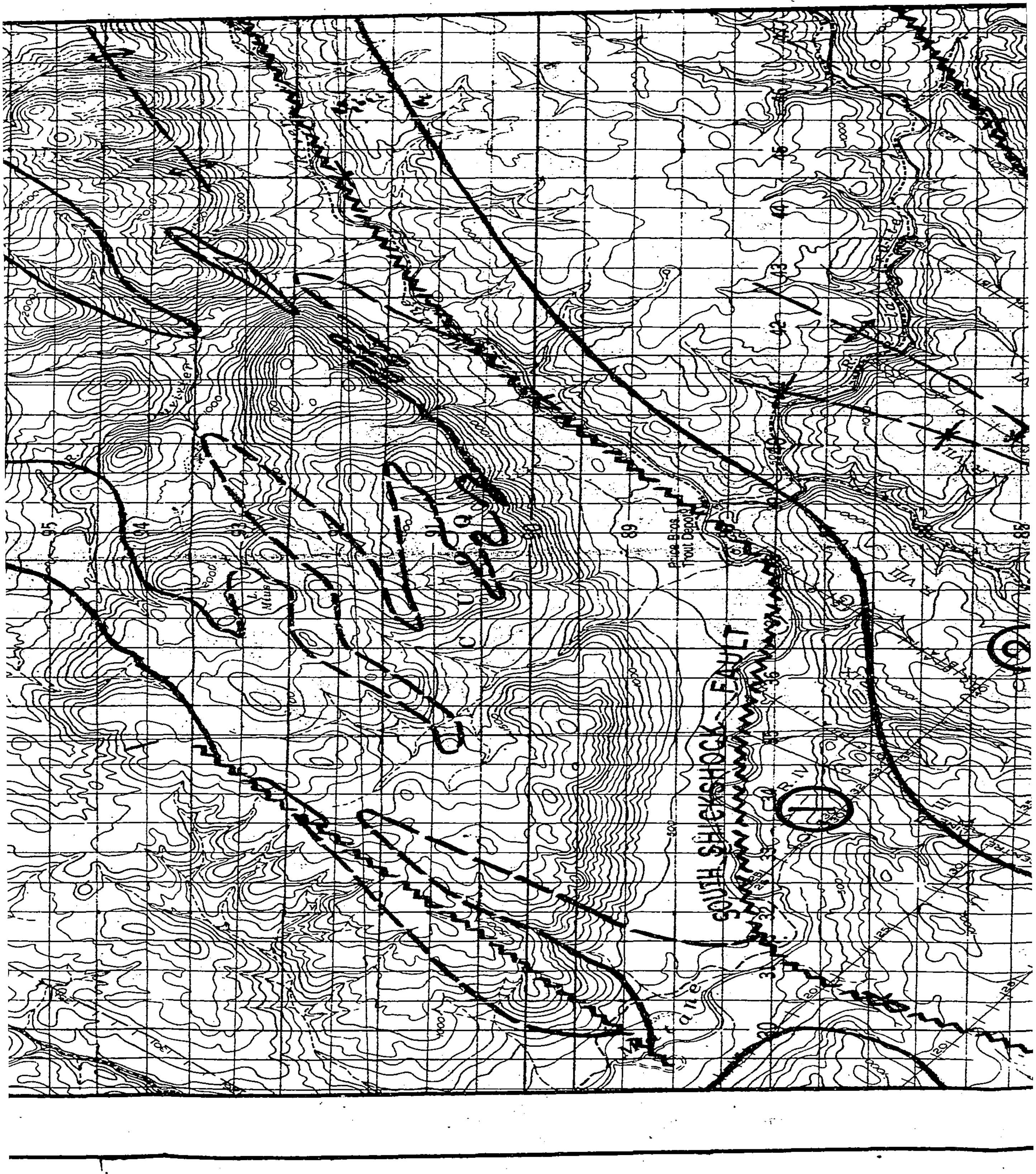
J.J.Raudsepp (1967)-Lithology and altitude
in Gaspé Peninsula.

CUOQ Sheet

CONTOUR INTERVAL: 100 feet.

SCALE: Gridded lines are at 0.5 Kilometer intervals.




SOUTH SHICKSHOCK FAULT
Price Bros.
Trout Depot
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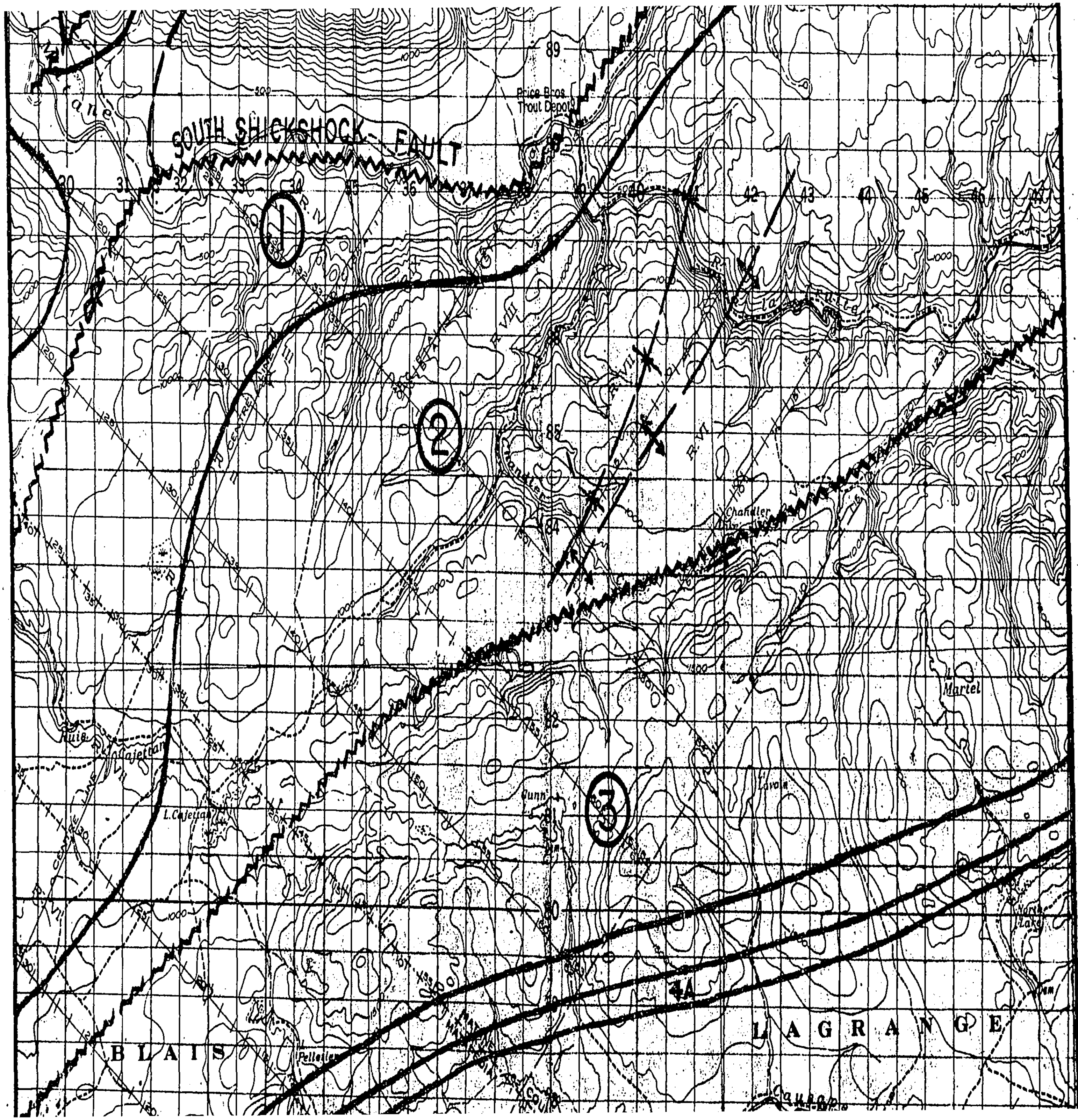
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R. VIII
R. VII
Chandler
L. Martel
Lavoie
Gunn
L. Cajetan
Pelletier
North Lake
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L A G R A N G E
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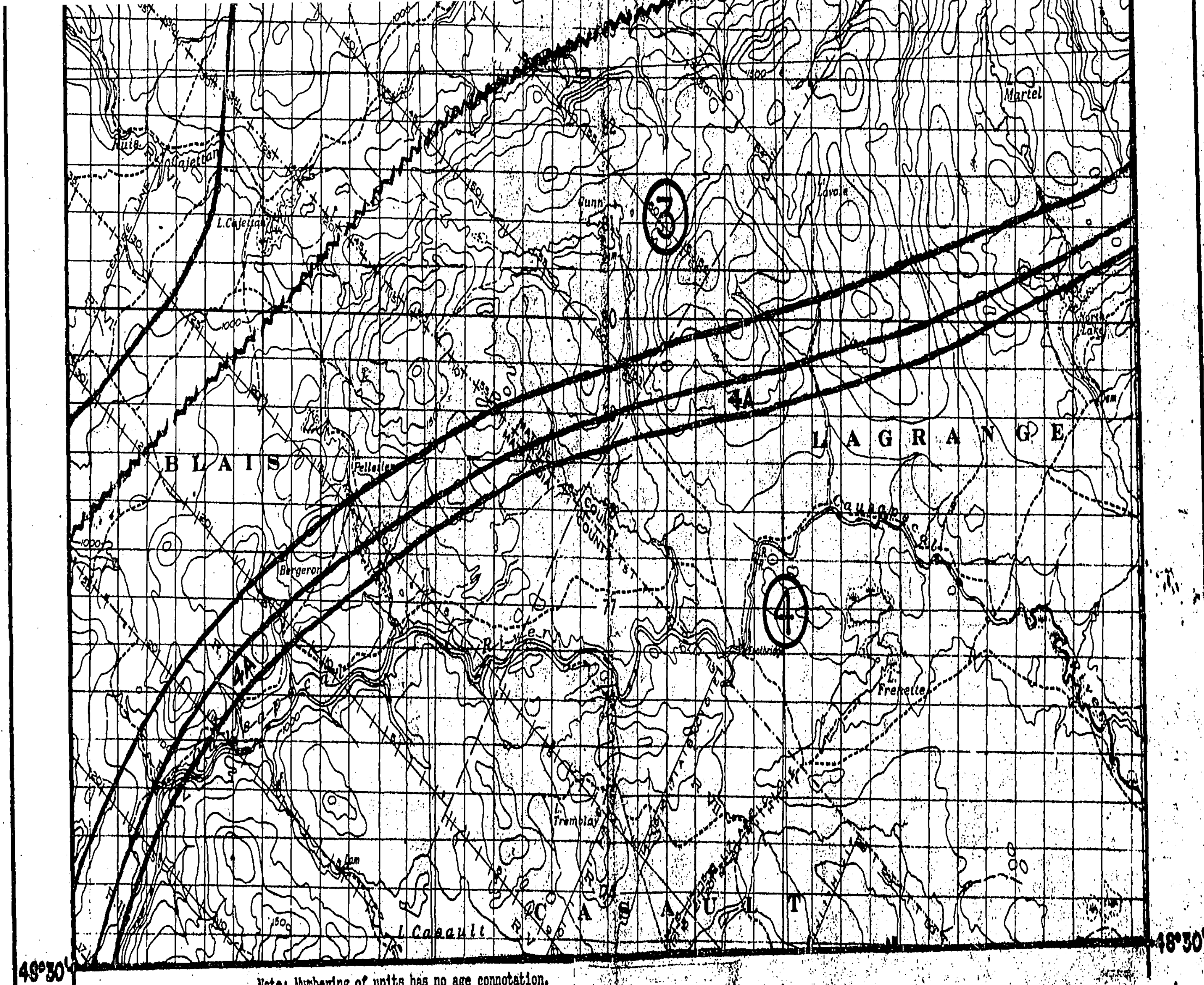


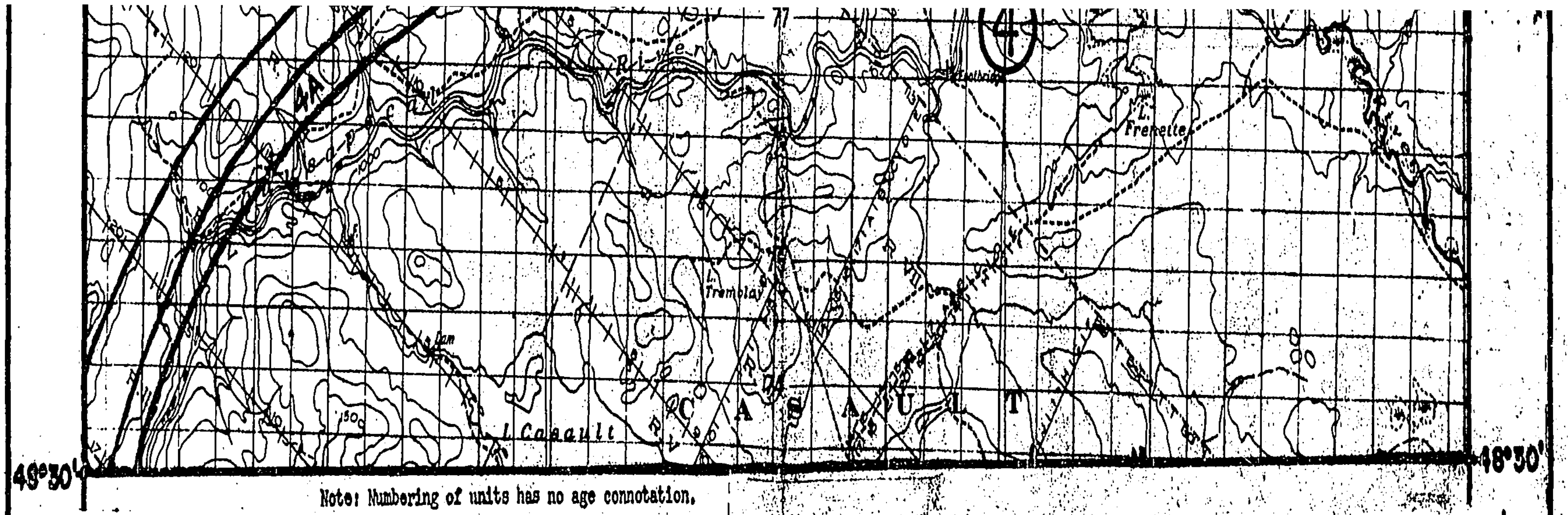
Note: Numbering of units has no age connotation.

①

<u>St. Leon Formation:</u> (Upper Silurian)
Light to medium greenish grey, calcareous siltstone and sandstone ; minor shale and limestone beds.

②

<u>Cape Bon Ami Formation:</u> (Lower Devonian)
Medium to dark grey, very fine grained, argillaceous



Note: Numbering of units has no age connotation.

① **St. Leon Formation:** (Upper Silurian)
Light to medium greenish grey, calcareous siltstone and sandstone ; minor shale and limestone beds.

② **Cape Bon Ami Formation:** (Lower Devonian)
Medium to dark grey, very fine grained, argillaceous to silty limestone ;

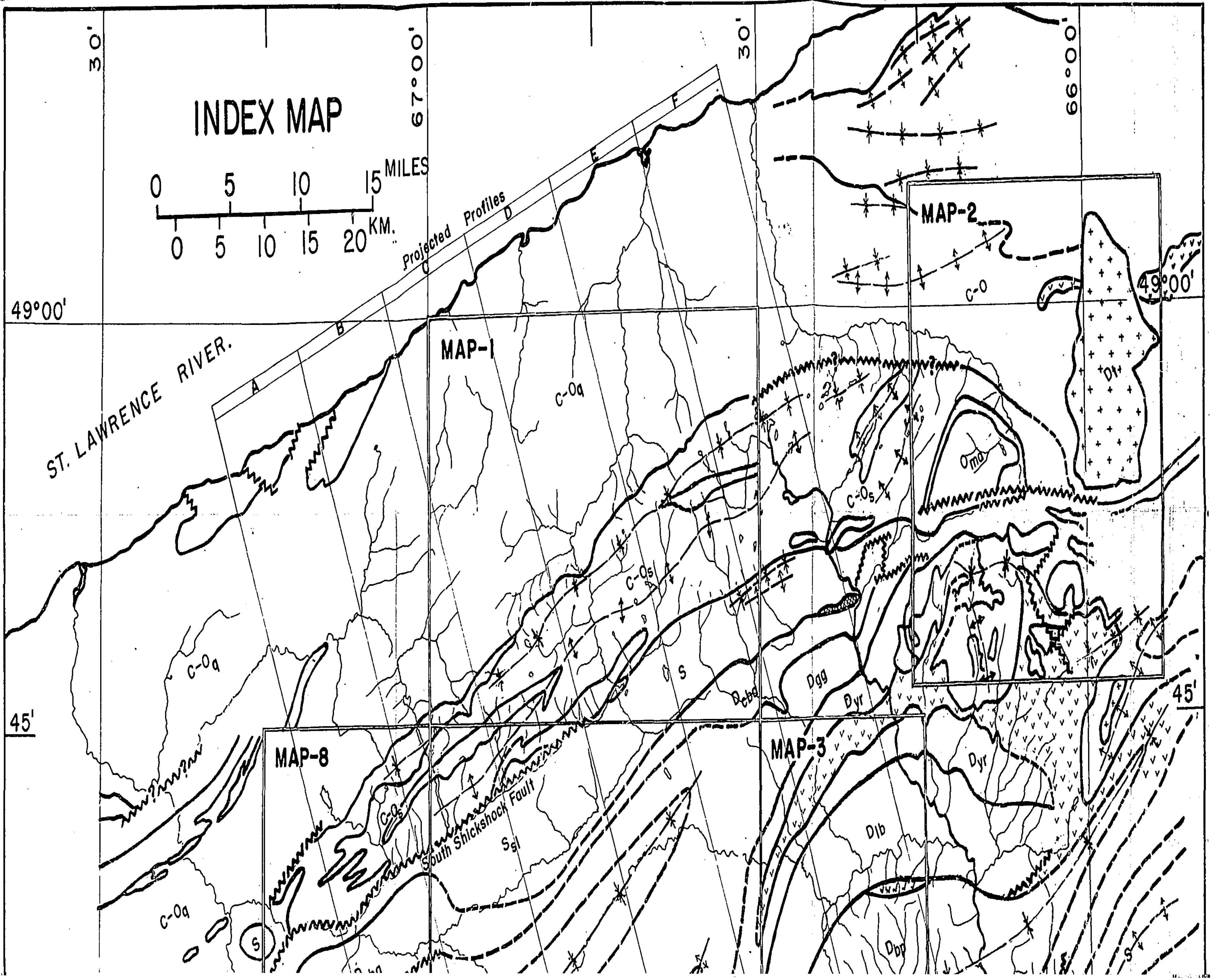
③ **Grande Grève Formation:** (Lower Devonian)
Medium grey, hard brittle, calcareous siltstone and siliceous limestone;

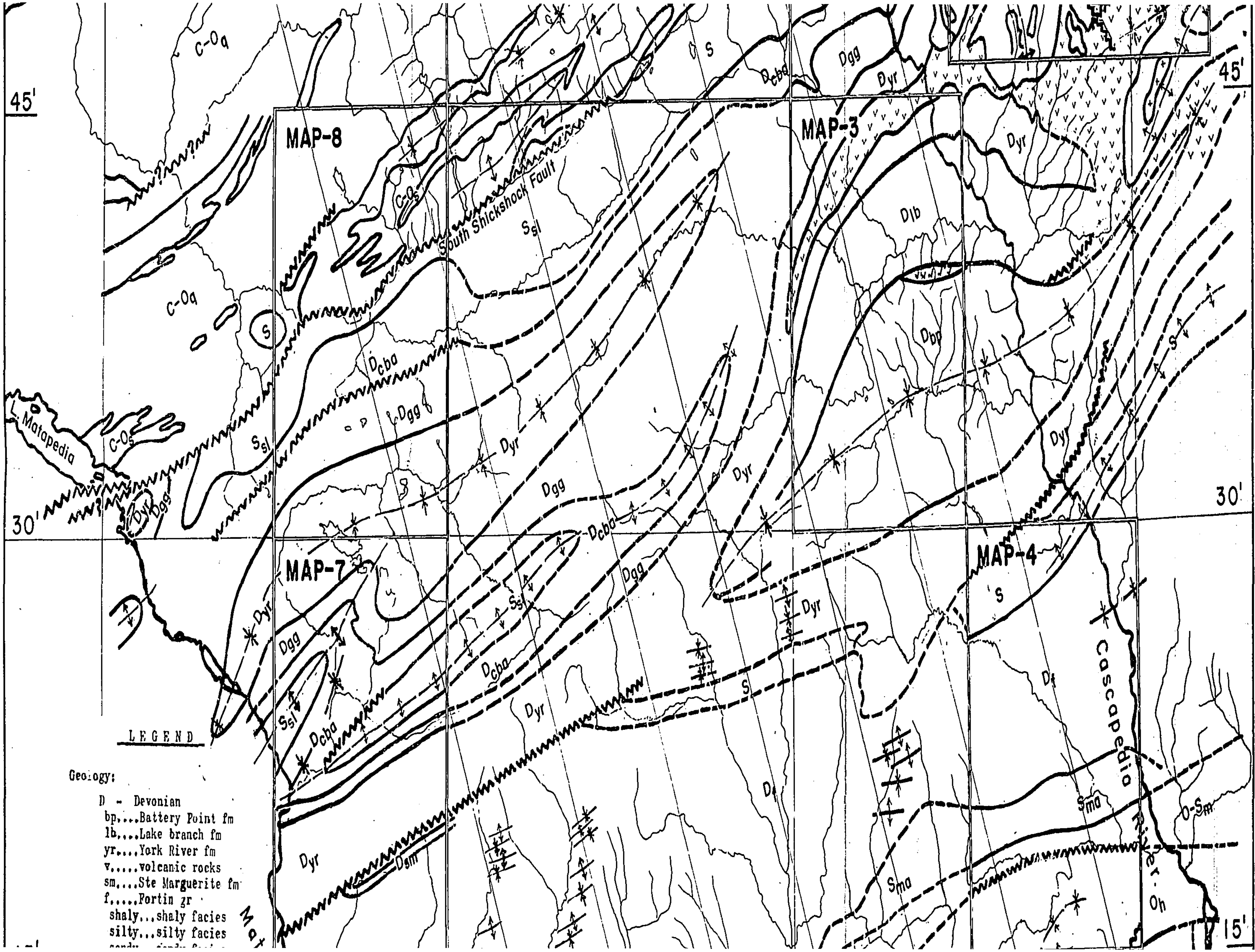
④ **York River Formation:** (Lower Devonian)
Light to medium grey, greenish grey, fine to very fine grained, feldspathic sandstone with interbeds of grey shale; (4A) band of fossiliferous, calcareous siltstone.

Topographic base: Canadian National Topographic System Sheet 22-B-11 (East).
Geology: Quebec Dept. Natural Resources, Preliminary Report No. 465,
(by N.C.Ollerenshaw, 1961).

MAP NO. 8

[illegible]

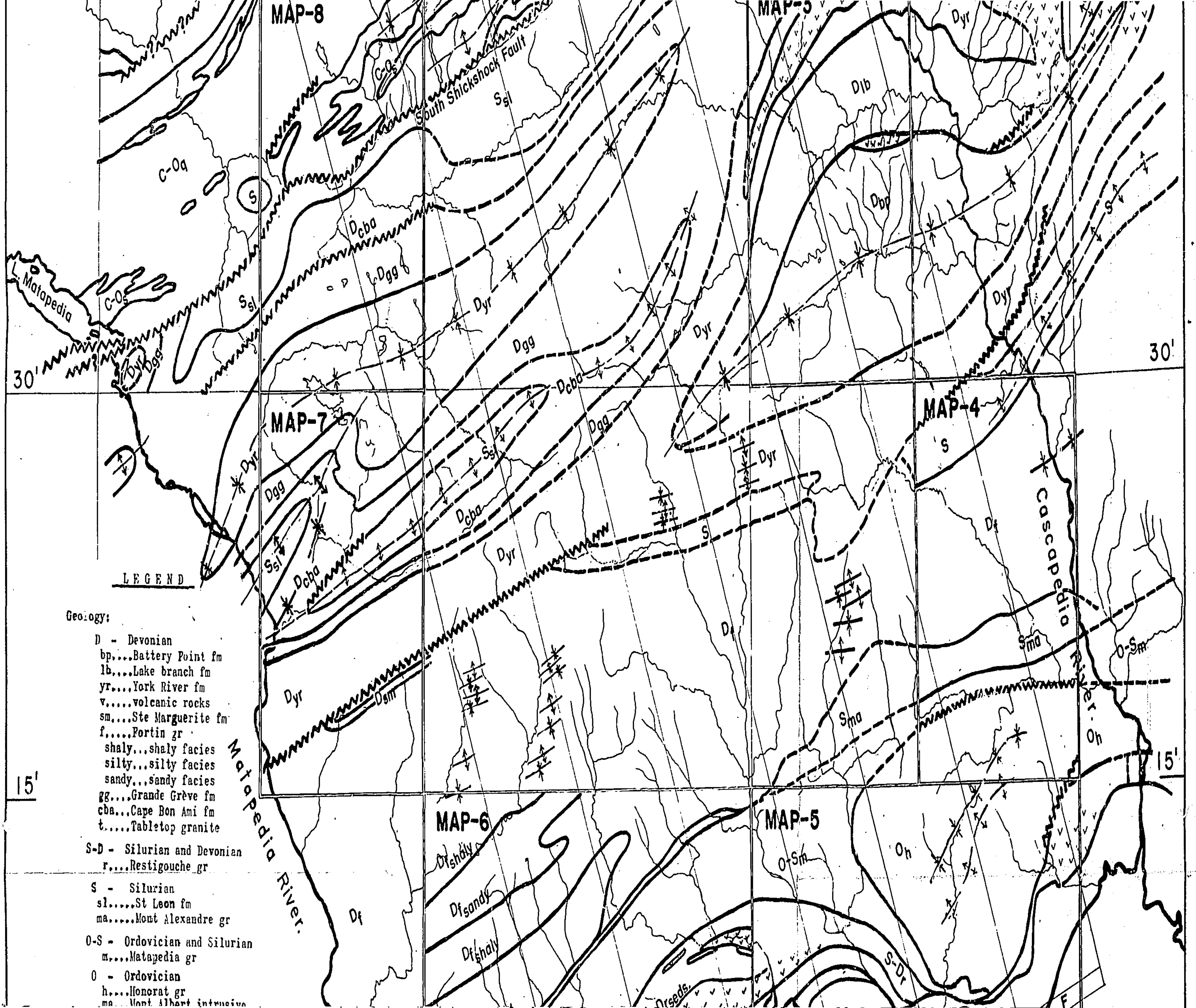

INDEX MAP
0 5 10 15 MILES
0 5 10 15 20 KM.
30'
67°00'
30'
66°00'
49°00'
49°00'
45'
45'
Projected Profiles
A
B
C
D
E
F
ST. LAWRENCE RIVER.
MAP-1
MAP-2
MAP-3
MAP-8
C-Oa
C-Os
C-O
Omd
Dt
S
Ssl
Dcbd
Dgg
Dyr
Dlb
Dbp
South Shickshock Fault



LEGEND

Geology:

D - Devonian
bp....Battery Point fm
lb....Lake branch fm
yr....York River fm
v.....volcanic rocks
sm....Ste Marguerite fm
f.....Fortin gr
shaly...shaly facies
silty...silty facies



LEGEND

Geology:

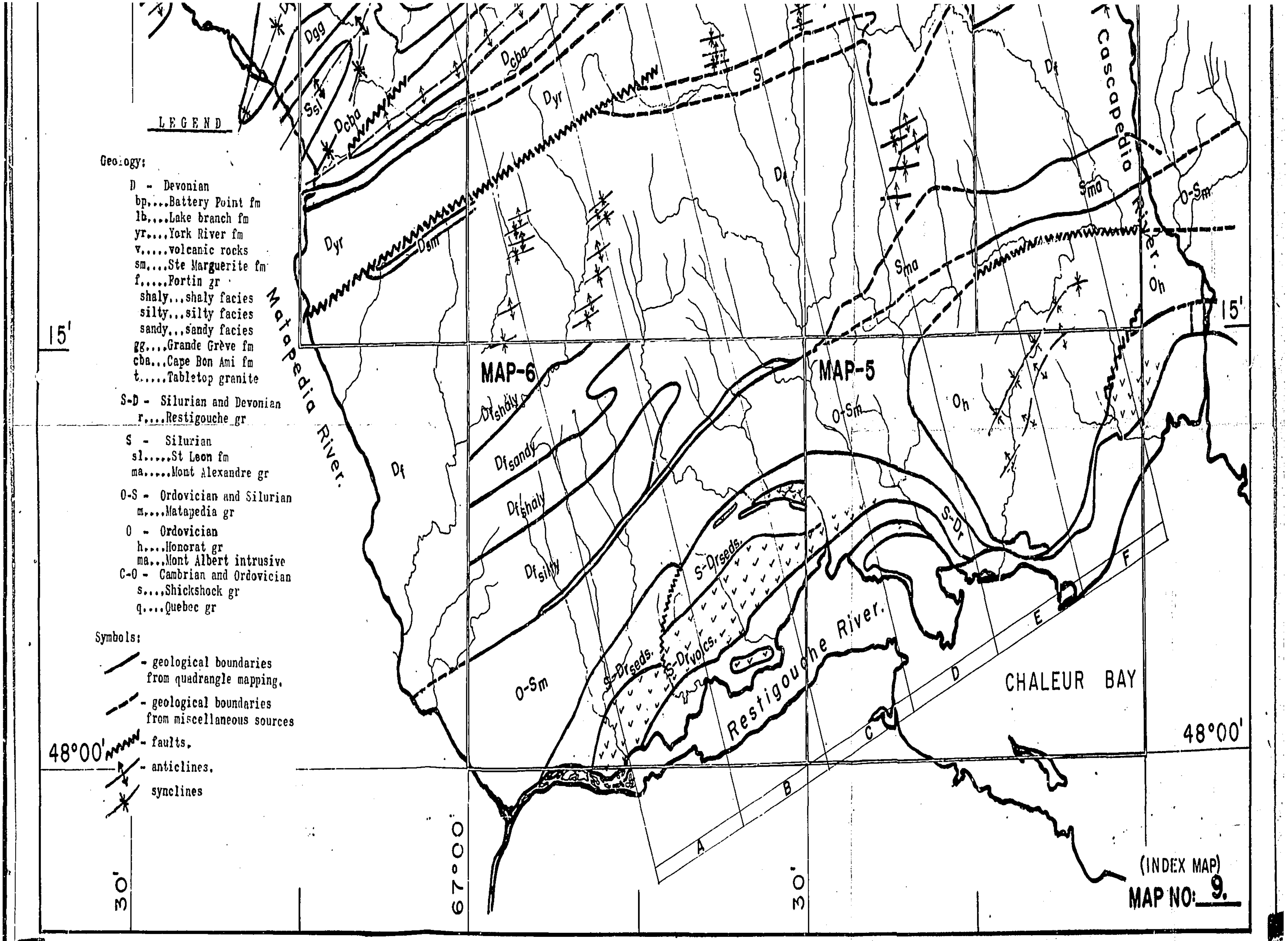
D - Devonian
bp....Battery Point fm
lb....Lake branch fm
yr....York River fm
v.....volcanic rocks
sm....Ste Marguerite fm
f.....Portin gr
shaly...shaly facies
silty...silty facies
sandy...sandy facies
gg....Grande Grève fm
cba...Cape Bon Ami fm
t.....Tabletop granite

S-D - Silurian and Devonian
r....Restigouche gr

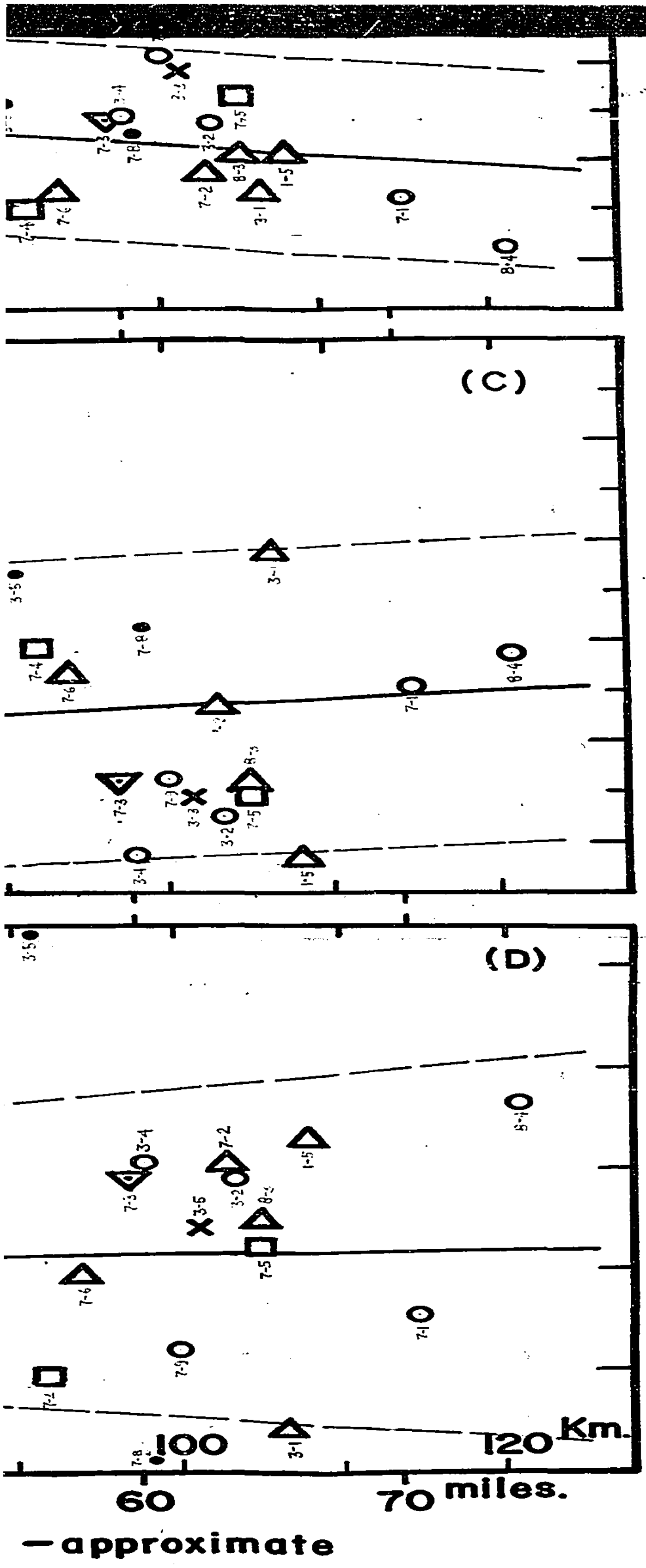
S - Silurian
sl.....St Leon fm
ma.....Mont Alexandre gr

O-S - Ordovician and Silurian
m....Matapedia gr

O - Ordovician
h....Honorat gr
ma...Mont Albert intrusive



J.J.Raudsepp (1967) Lithology and altitude in Gaspé Peninsula.



EQUATIONS of TREND LINES
FITTED BY LEAST SQUARES METHOD

Note: distance (D) is in Kilometers.

MEAN ALTITUDE trend:

$\overline{X} = 924.7 \text{ ft} + 3.372(D)$

STANDARD DEVIATION trend:

$S.D. = 321.6 \text{ ft} - 1.050(D)$

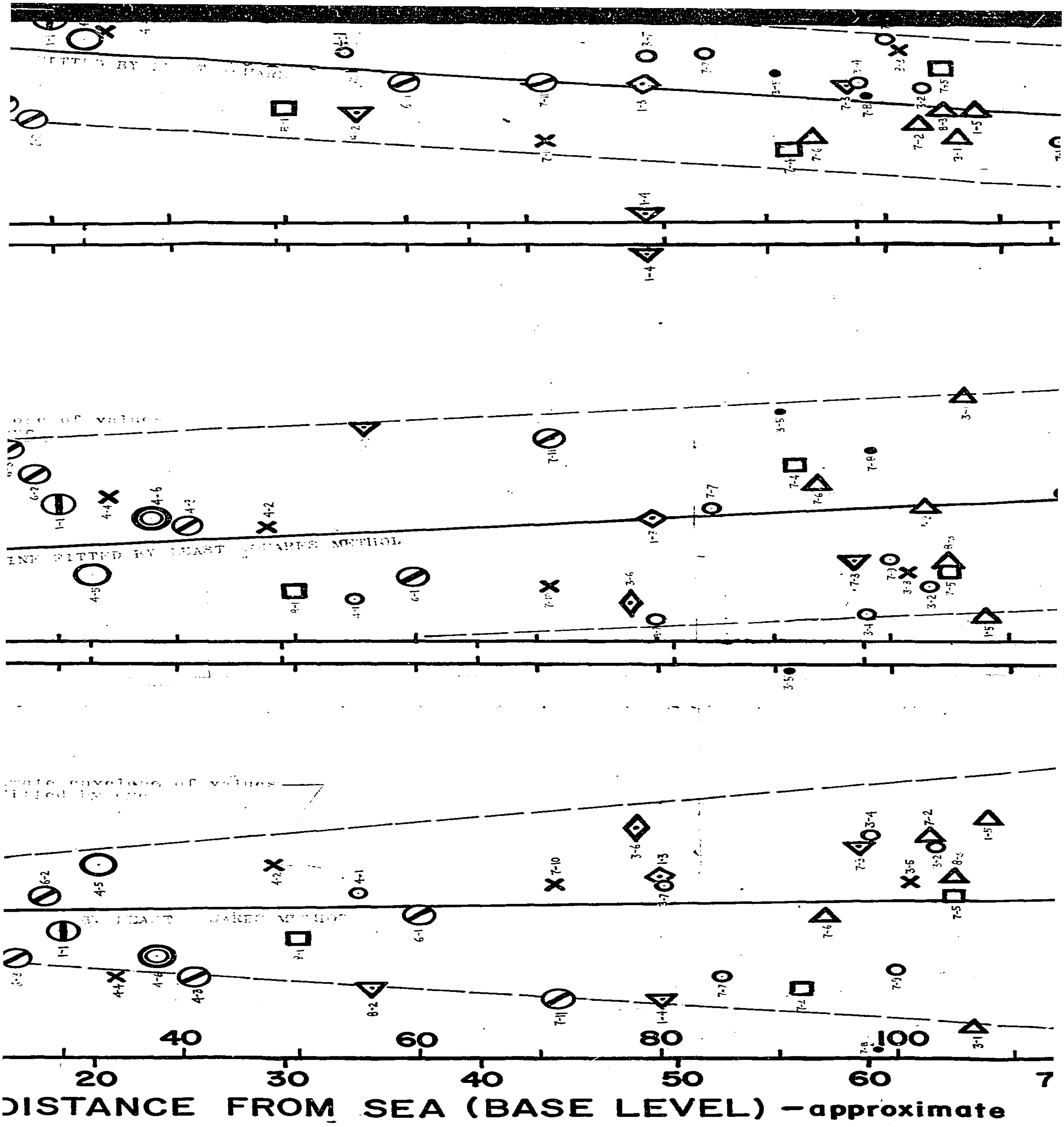
KURTOSIS trend:

$K = 2.6024 + 0.00735(D)$

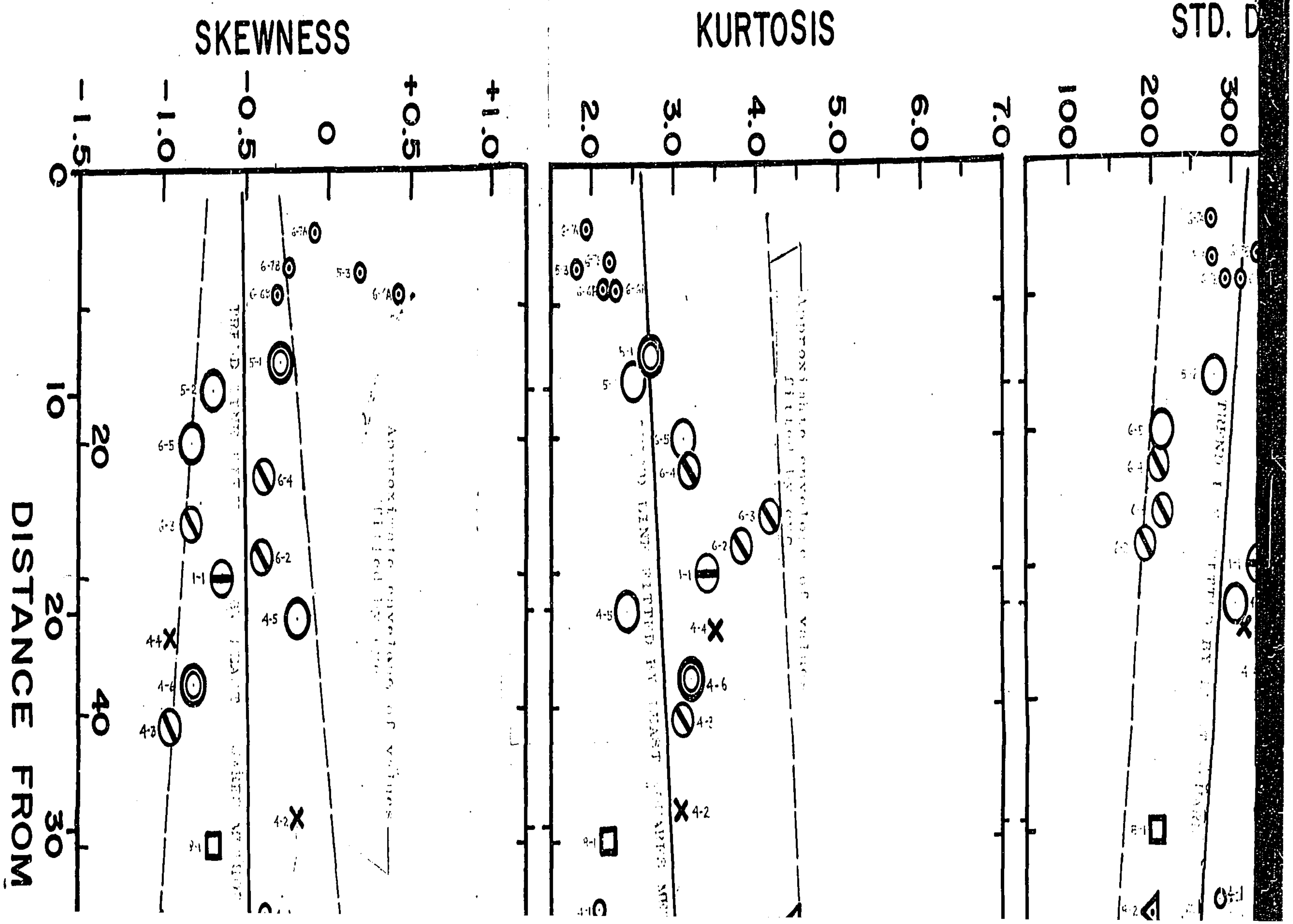
SKEWNESS trend:

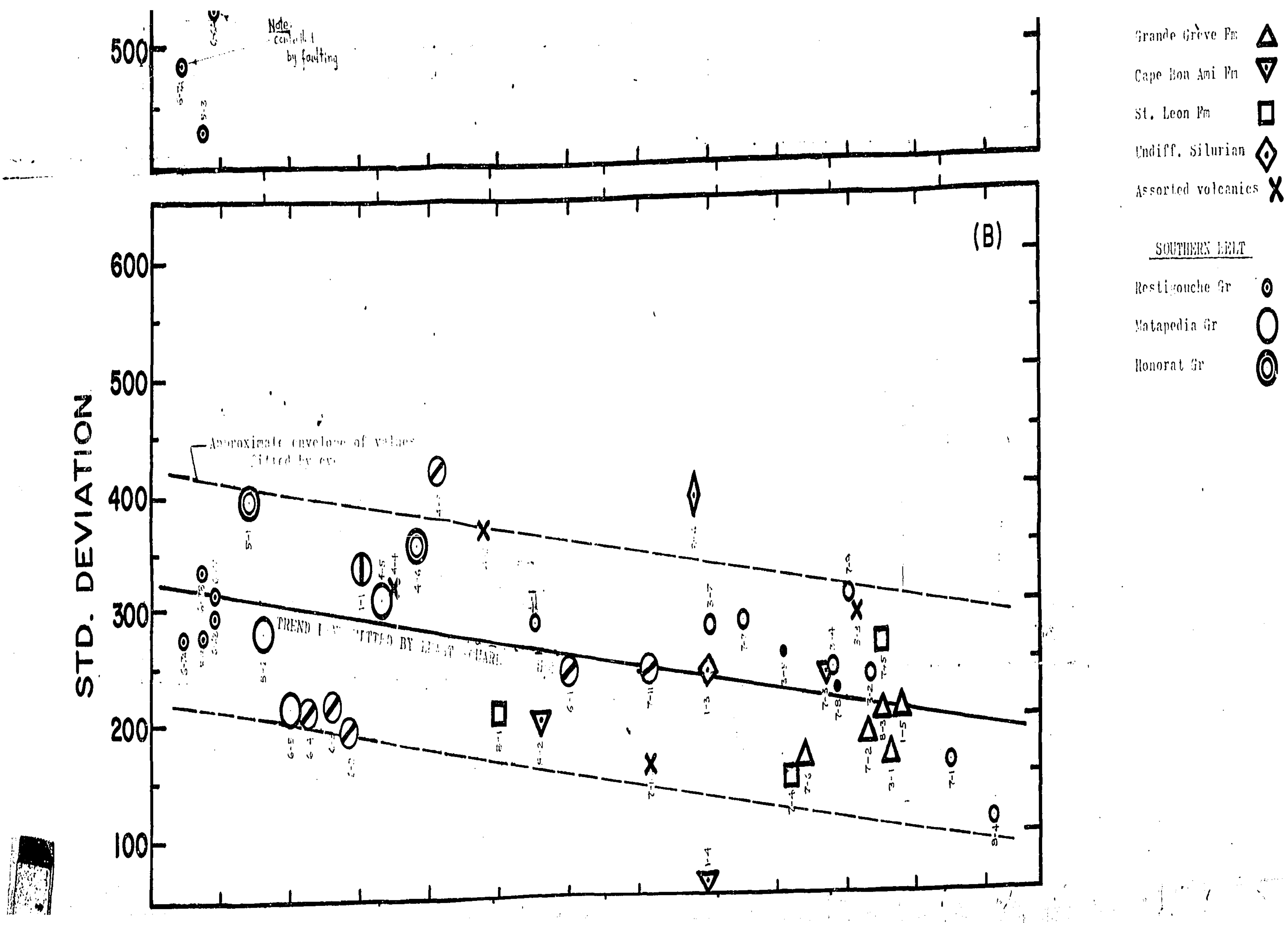
$SK = -0.5118 + 0.00034(D)$

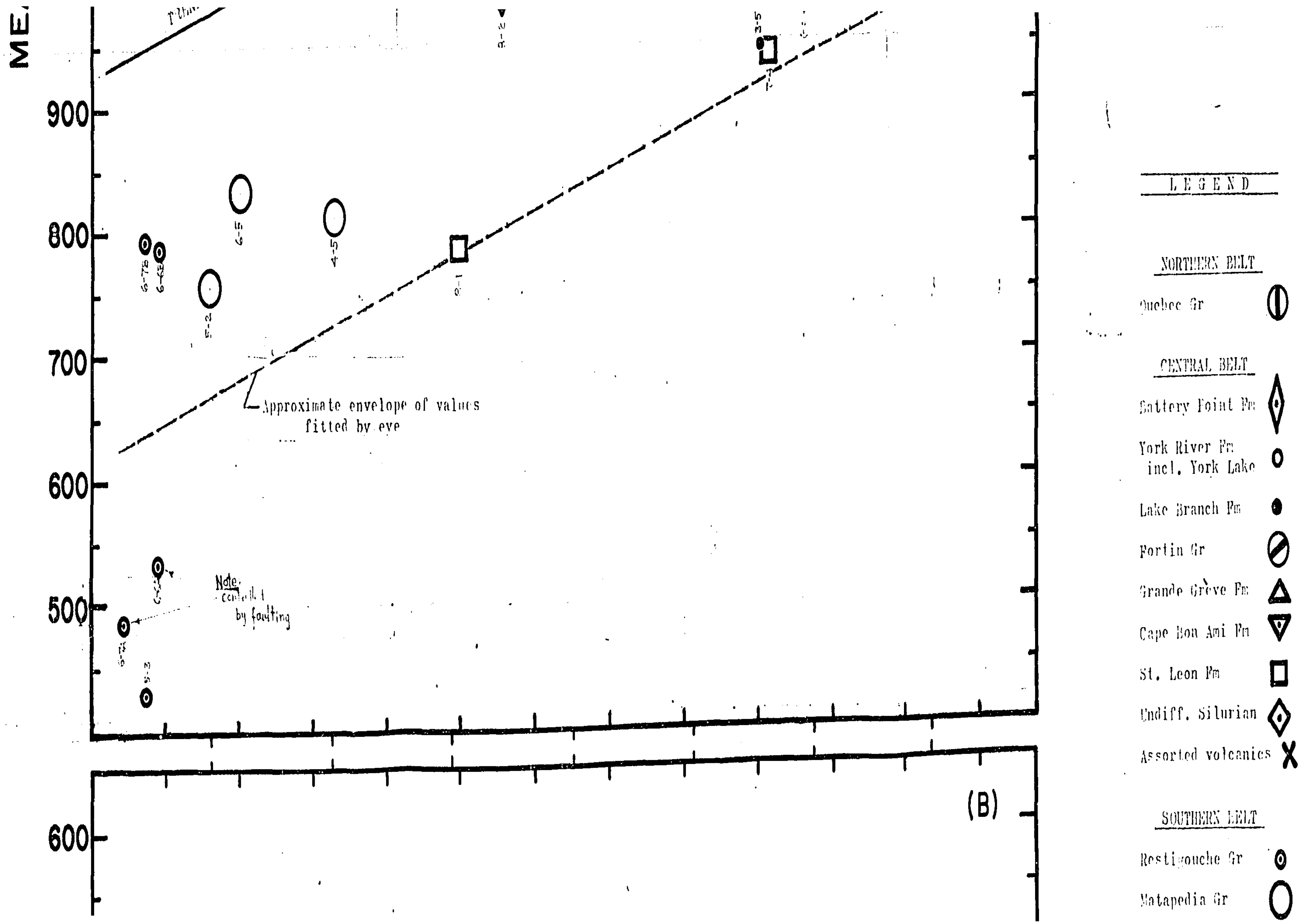
Figure 100 – Plot of frequency distribution parameters of altitude populations supported by various rock-units, in western Gaspé -vs- distance from sea (base level).

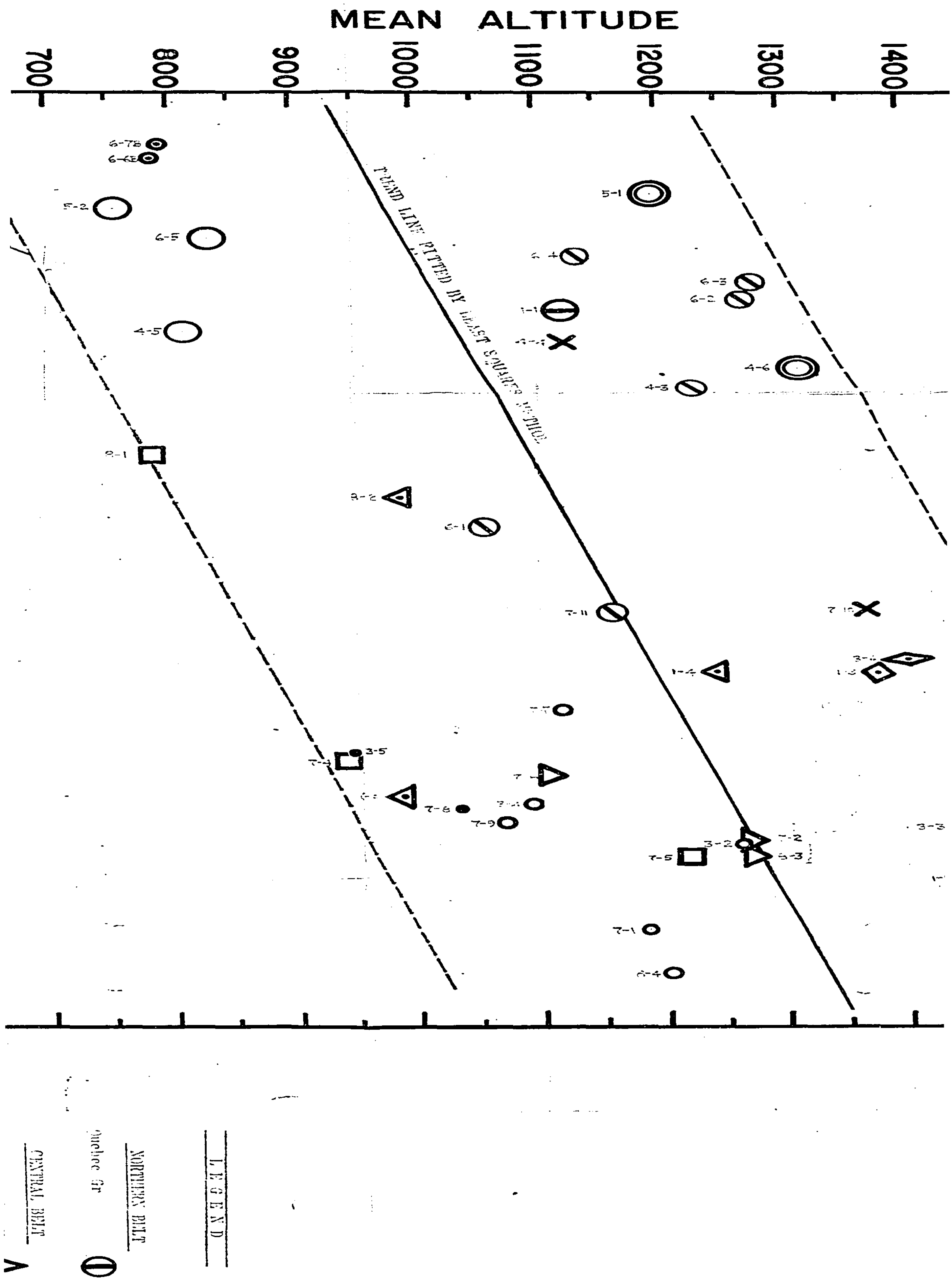


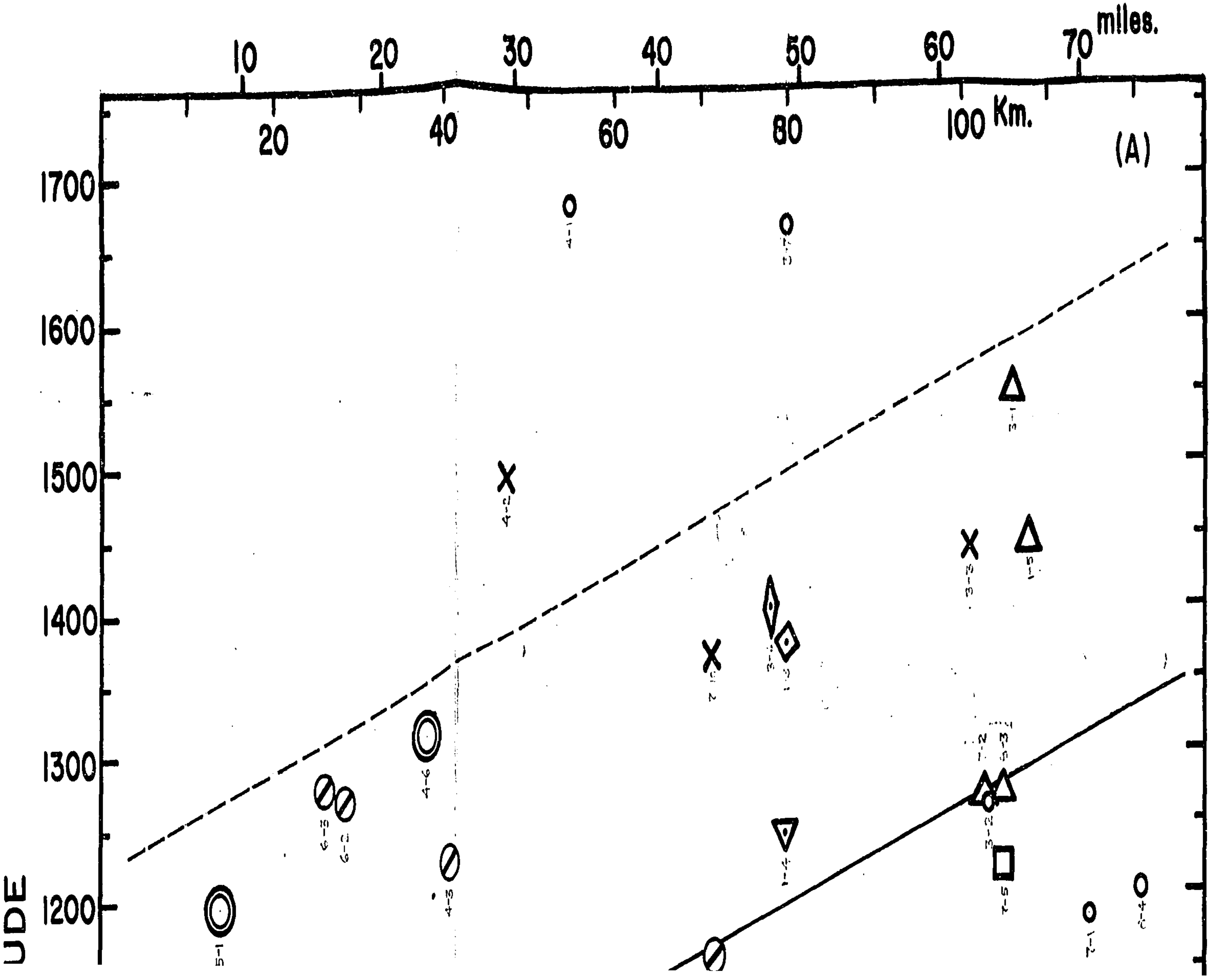
...mate envelope of values
...itted by eye
...LINE FITTED BY LEAST SQUARES METHOD
...ope of values
...FITTED BY LEAST SQUARES
20
40
30
60
40
80
50
100
60
7
DISTANCE FROM SEA (BASE LEVEL) —approximate
6-3
6-2
1-1
4-5
4-4
4-6
4-3
4-2
8-1
4-1
8-2
6-1
7-11
7-10
3-6
1-3
3-7
1-4
7-7
7-4
7-6
7-3
3-4
7-8
7-9
3-5
7-2
3-2
8-3
7-5
3-1
1-5
3-3
1-2


SKEWNESS
KURTOSIS
STD. D
DISTANCE FROM
-1.5
-1.0
-0.5
0
+0.5
+1.0
2.0
3.0
4.0
5.0
6.0
7.0
100
200
300
0
10
20
30
20
40
Approximate envelope of values
TREND LINE FITTED BY LEAST SQUARES
6-7A
6-7B
6-6
5-3
6-4A
5-1
5-2
6-5
6-4
6-3
6-2
1-1
4-5
4-4
4-6
4-3
4-2
9-1
4-1
8-1


STD. DEVIATION
100
200
300
400
500
600
500
(B)
Note: controlled by faulting
Approximate envelope of values fitted by eye
TREND LINE FITTED BY LEAST SQUARE
5-1
5-2
5-3
6-5
6-4
4-5
4-4
4-6
1-1
8-1
6-2
6-1
7-11
1-3
1-4
3-7
3-4
3-2
3-1
7-2
7-3
7-4
7-5
7-6
7-8
7-9
7-1
8-3
1-5
9-4
Grande Grève Fm
Cape Bon Ami Fm
St. Leon Fm
Undiff. Silurian
Assorted volcanics
SOUTHERN BELT
Restigouche Gr
Matapedia Gr
Honorat Gr


ME
900
800
700
600
500
600
(B)
6-7B
6-6B
5-2
6-5
4-5
8-1
3-5
8-2
5-3
Note:
controlled
by faulting
Approximate envelope of values
fitted by eye
LEGEND
NORTHERN BELT
Quebec Gr
CENTRAL BELT
Battery Point Fm
York River Fm
incl. York Lake
Lake Branch Fm
Fortin Gr
Grande Grève Fm
Cape Bon Ami Fm
St. Leon Fm
Undiff. Silurian
Assorted volcanics
SOUTHERN BELT
Restigouche Gr
Matapedia Gr


MEAN ALTITUDE
700
800
900
1000
1100
1200
1300
1400
TREND LINE FITTED BY LEAST SQUARES METHOD
LEGEND
NORTHERN BELT
Quebec Gr
CENTRAL BELT
6-7B
6-6B
5-1
5-2
6-5
6-4
6-3
6-2
1-1
4-5
4-6
4-3
8-1
8-2
6-1
7-11
1-4
3-5
7-5
3-2
7-2
3-3
7-8
7-9
7-1
6-4


UDE
1200
1300
1400
1500
1600
1700
10
20
30
40
50
60
70
miles.
20
40
60
80
100 Km.
(A)
5-1
6-3
6-2
4-6
4-3
4-2
4-1
3-7
3-4
1-3
1-4
3-3
1-5
3-1
7-2
5-3
3-2
7-5
7-1
6-4