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GEOLOGY OF THE PLASTER ROCK (EAST HALF) MAP AREA, NEW BRUNSWICK

R. SKINNER

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W.H. Poole

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CONTENTS

Figures

GEOLOGY OF THE PLASTER ROCK (EAST HALF) MAP AREA, NEW BRUNSWICK

Abstract

Plaster Rock (east half) map area lies in the Appalachian Mountain system in the Chaleur Uplands.

Most of the map area occupies part of the east limb of the Chaleur Bay Synclinorium and is underlain by a north-northeasterly trending Lower Devonian, largely very low grade metamorphic volcanic-sedimentary assemblage called the Tobique Group. This consists of a lower unit, the Costigan Mountain Formation of mainly rhyolitic rocks, and a conformably overlying unit, the Wapske Formation of mainly intercalated basalt, slate and greywacke.

The Tobique Group unconformably overlies cataclastic Ordovician granitic rocks in the southeast corner, and is overlain unconformably by flat-lying Mississippian(?) conglomerate, sandstone and shale in the northwest. Devonian diabase sills, dykes and stocks intrude the Lower Devonian strata.

Lead, zinc, copper, silver and gold mineralization is present in the Rhyolitic unit of the Costigan Mountain Formation.

Résumé

Le secteur de Plaster Rock (moitié est) se situe dans le système des Appalaches, sur les bas-plateaux des Chaleurs.

Dans sa majeure partie, le secteur occupe une portion du membre est du synclinorium de Chaleurs Bay, et contient dans son sous-sol un assemblage volcano-sédimentaire très faiblement métamorphisé, d'orientation nord nord-est, d'âge Dévonien inférieur, appelé groupe de Tobique. Celui-ci consiste en une unité inférieure, la formation de Costigan Mountain, principalement formée de roches rhyolitiques, et une unité sus-jacente concordante, la formation de Wapske, qui contient en alternance surtout des basaltes, ardoises et grauwakes.

Dans le coin sud-est, le groupe de Tobique repose en discordance sur des roches cataclastiques ordoviciennes granitiques; il est recouvert en discordance au nord-ouest par des conglomérats, grès et argiles litées d'allure horizontale, d'âge Mississipien (?). Des sills, dykes et amas de diabase sont intrusifs dans les couches du Dévonien inférieur.

Dans l'unité rhyolitique de la formation de Costigan Mountain, a eu lieu une minéralisation en plomb, zinc, cuivre, argent et or.

INTRODUCTION

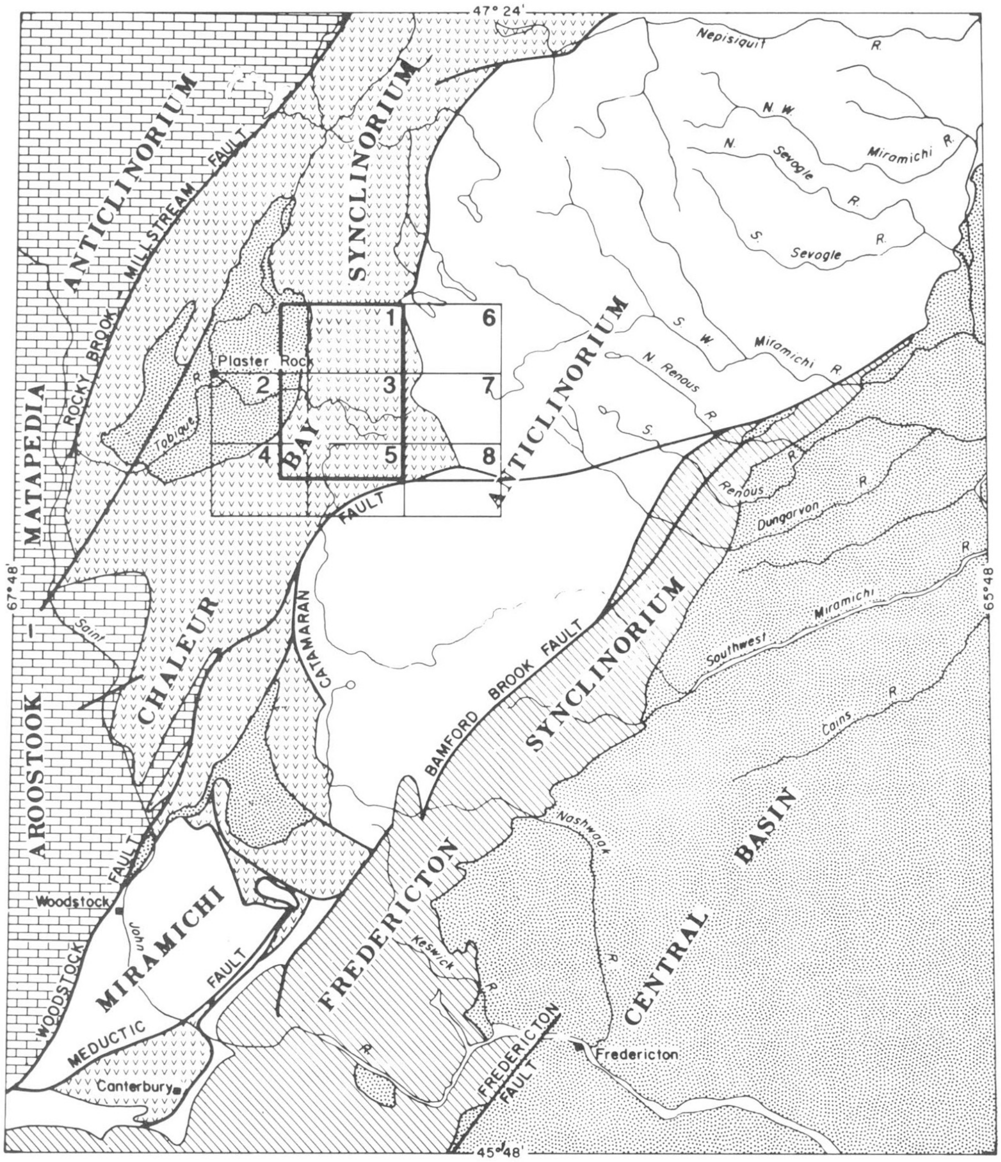
Plaster Rock (east half) map area lies on the western flank of the Miramichi Anticlinorium, a belt of highly deformed Ordovician volcanic, sedimentary and intrusive rocks that extend northeasterly across the province from Woodstock to Bathurst. The map area is 110 km west of Newcastle and 75 km northeast of Woodstock, New Brunswick.

The Miramichi Anticlinorium and Chaleur Bay Synclinorium to the west have long been known for their base metal, gold and silver occurrences. In 1949 the Geological Survey of Canada began in the Bathurst area a 1 inch to 1 mile mapping program to determine the stratigraphy, structure, igneous, metamorphic and tectonic history of the Central Mineral Belt of New Brunswick to provide a geological data base for mineral exploration. Plaster Rock map area is one of the last areas mapped during the program. In 1974 lead, zinc, copper and fluorite were discovered in Costigan Mountains in the northeast part of the Plaster Rock map area.

Field work was carried out by R. Skinner during the summer of 1970, and able assistance was given by D.V. Venugopal, Robert Bowlby, John Godfrey and Peter Hooper (cook). The writer is indebted to employees of The Fraser Companies Limited, Irving Pulp and Paper Limited and New Brunswick Forest Service for assistance and co-operation. W.H. Poole of the Geological Survey of Canada critically reviewed the manuscript and suggested many improvements and additional background material. The writer gratefully appreciates his contributions.

Since the Plaster Rock (east half) map area was mapped by Skinner in 1970, the New Brunswick Mineral Resources Branch, assisted by the federal Department of Regional Economic Expansion, carried out detailed mapping within the area. Their map areas are 6 minutes of latitude (from north to south) by 12 minutes of longitude (from east to west) and were published on a scale of 1 inch to 1/4 mile. Of the five areas partly or entirely within Plaster Rock (east half) map area (Fig. 1), R.R. Irrinki (1977c) mapped one and C. St. Peter (1978, 1979, in preparation) mapped four. The maps resulting from this work were used to supplement Skinner's data where information was lacking along the smaller streams and in some of the interstream areas. Their work is gratefully acknowledged.

Figure 2 shows Geological Survey of Canada maps along the Miramichi Anticlinorium in the vicinity of the Plaster Rock (east half) map area.



CARBONIFEROUS

Sandstone, conglomerate, shale; minor volcanic rocks, limestone and gypsum

SILURIAN and DEVONIAN

Felsic and mafic volcanic rock, slate, sandstone; minor limestone, conglomerate, gabbro and granite

SILURIAN

Greywacke, slate, and minor conglomerate; includes younger granite

ORDOVICIAN and SILURIAN

Limestone, slate, sandstone; minor conglomerate

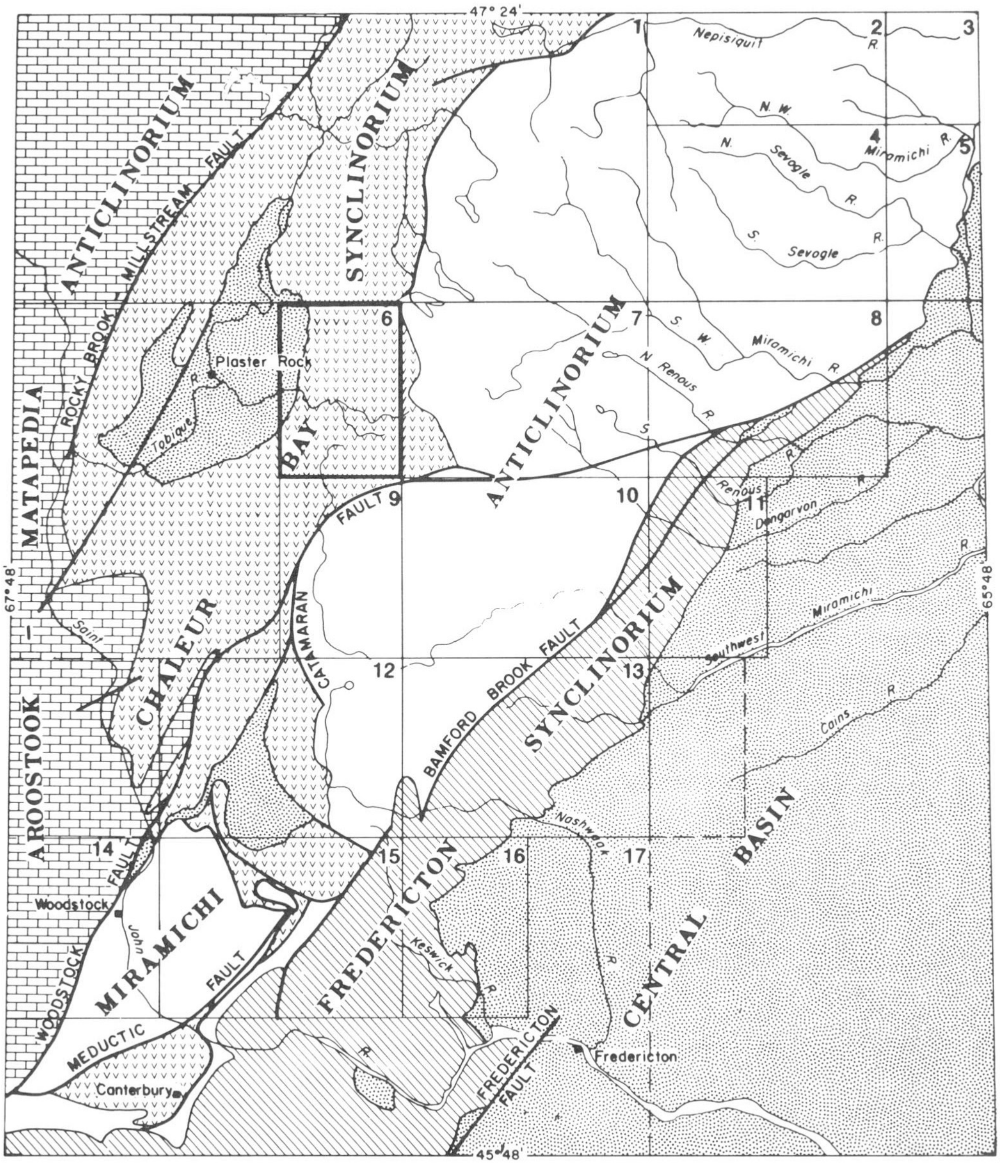
CAMBRO - ORDOVICIAN

Polydeformed quartzite, felsic and mafic volcanic rocks, greywacke, slate, paragneiss, migmatite; deformed gabbro and granite; younger gabbro and granite plutons

1. *South Branch Gulquac River, J-12 map area (Irrinki, 1977c).*
2. *Wapske-Oven Rock Brook, I-13 map area (St. Peter, 1979).*
3. *Head of Wapske River, J-13 map area (St. Peter, 1978).*
4. *Upper Odell River - Summit, I-14 map area (St. Peter, 1979).*
5. *Upper Part of North Branch Southwest Miramichi River, J-14 map area (St. Peter, in preparation).*
6. *Gulquac and Island Lakes, K-12 map area (Crouse, 1977).*
7. *Head of Clearwater Brook, K-13 map area (Crouse, 1978).*
8. *Parts of Burnhill and Clearwater Brook, K-14 map area (Crouse, 1979).*

0 Kilometres 30

Figure 1. Index map showing location of New Brunswick Mineral Resources Branch 1 inch to 1/4 mile geological maps with respect to Plaster Rock (east half) map area. (Figure base courtesy of New Brunswick Mineral Resources Branch.)



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1. *Tobique map area, N.B. (21 "O" (1 inch to 2 miles) (Anderson, 1962).*
2. *California Lake map area, N.B. (21-O/8) (Smith et al., 1973).*
3. *Nepisiquit Falls map area, N.B. (21 P/5) (Skinner, 1974).*
4. *Big Bald Mountain map area, N.B. (21-O/1) (Anderson, 1970a).*
5. *Sevagle map area, N.B. (21 P/4, W½) (Dawson, 1961).*
6. *Plaster Rock (east half) map area, N.B. (21 J/14, E½) this report.*
7. *Tuadook Lake map area, N.B. (21 J/15 (Skinner, 1975).*
8. *McKendrick Lake map area, N.B. (21 J/16) (Anderson, 1970b).*
9. *Juniper (east half) map area, N.B. (21 J/11, E½) (Skinner, 1972).*
10. *Hayesville map area, N.B. (21 J/10) (Poole, 1963).*
11. *McNamee map area, N.B. (21 J/9, W½) (Poole, 1960).*
12. *Coldstream map area, N.B. (21 J/6) (Anderson, 1968).*
13. *Napadogan map area, N.B. (21 J/7 (Poole, 1958).*
14. *Woodstock map area, N.B. (21 J/4) (Anderson, 1968).*
15. *Millville map area, N.B. (21 J/3) (Anderson, 1968).*
16. *Burtts Corner, N.B. (21 J/2, W½) (Poole, 1957).*
17. *Woodstock-Fredericton, N.B. (21G and 21J parts of) (1 inch to 2 miles) (Anderson and Poole, 1959).*

0 Kilometres 30

Figure 2. *Index map showing Geological Survey of Canada geological maps mainly 1 inch to the mile or 1:50 000 in the vicinity of the Plaster Rock (east half) map area, New Brunswick. (Figure base courtesy of New Brunswick Mineral Resources Branch).*

Accessibility

There is no permanent habitation within the map area; the nearest community is Plaster Rock, a village of less than 1000 people, 10 km to the west. The map area is accessible from the Trans-Canada Highway via secondary Highway 108 at Grand Falls from the north, or Highway 109 at Perth-Andover from the south. Both highways lead easterly to Plaster Rock where the Plaster Rock-Renous Highway (108) crosses the north-central part of the map area. Logging roads lead north and south off the highway within the map area and a similar road goes up to the south side of Wapskehegan River from its mouth, 10 km west of the area, south of Plaster Rock.

There are no streams or lakes within the map area suitable for canoes or float planes and all travel off the highway is by truck or car on logging roads and then by foot along streams, or across country through thick bush. The south-central part of the area is the most inaccessible and can best be reached from a logging road in the northeast part of the Juniper (east half) map area.

Physical Features

The map area lies on the Chaleur Uplands and borders on the Miramichi Highlands to the east (Weeks, 1957). The Miramichi Highlands is the western part of the New Brunswick Highlands of Bostock (1970). The upland is hilly, slopes westward and is deeply incised by the westward flowing Gulquac and Wapskehegan rivers. Rhyolite underlies the most prominent hills and ridges. The highest point is 670 m (Costigan Mountain) in the Costigan Mountains[1] in the northeastern part of the map area, where the relief is about 230 m (Fig. 3). The lowest point, 145 m, is on Gulquac River in the northwestern part of the map area where the relief is about 60 m. The Gulquac and Wapskehegan rivers have cut V-shaped valleys up to 150 m deep and their local direction of flow is largely influenced by bedrock trend or jointing.

Outcrops are plentiful along deeply incised streams, such as Gulquac and Wapskehegan rivers and their main tributaries, and common in interstream areas in the more rugged eastern part of the map area.

Glaciation

The map area was glaciated during the Pleistocene. A thin mantle of glacial till covers the hills and is thicker on the sides of the hills and in the valleys. Glacial features and deposits are not prominent in the area and only two probable glacial striae were seen, one on a basalt outcrop in the southeastern part of the area, the other on a basalt outcrop along the roadside on the east side of the map area north of Gulquac River. The trends are southeasterly.

GENERAL GEOLOGY

The rocks of west-central New Brunswick have been divided into three north-northeasterly trending tectono-stratigraphic zones, from east to west: the Miramichi Anticlinorium, the Chaleur Bay Synclinorium and the Plaster Rock Basin (Ruitenberg et al., 1977).

The Miramichi Anticlinorium (Rodgers, 1970, 1971) is underlain by highly deformed, metamorphosed Cambrian and/or Ordovician sedimentary and volcanic rocks intruded by deformed Ordovician and undeformed Devonian granitic and gabbroic rocks. The degree of metamorphism varies from greenschist facies in the Bathurst area (Helmstaedt, 1973; Skinner, 1974) to upper amphibolite facies in the Tuadook Lake (Skinner, 1975) and Hayesville (Poole, 1963) areas to greenschist facies in the Woodstock area (Anderson, 1968).

The Chaleur Bay Synclinorium (Rodgers, 1970) is underlain by open folded, slightly metamorphosed Lower Devonian volcanic and sedimentary rocks which rest unconformably on Miramichi Anticlinorium rocks to the east and are overlain unconformably by flat-lying to gently dipping Mississippian(?) strata (Rose, 1936) of the Plaster Rock Basin (St. Peter, 1978).

The Plaster Rock (east half) map area is underlain mainly by deformed northerly trending Lower Devonian very low grade metamorphic volcanic and sedimentary rocks of the Tobique Group that unconformably overlie cataclastic Ordovician granitic rocks in the southeastern corner, and are overlain unconformably by flat-lying Mississippian(?) red conglomerate, sandstone and shale, the Arthurette Redbeds in the west. Devonian diabase sills, dykes and stocks intrude the Lower Devonian strata. Promising lead, zinc, copper, silver and gold mineralization is present in the Rhyolitic unit of the Costigan Mountain Formation.

Ordovician (Og)

The oldest rocks in the map area are grey to pink, cataclastic granite, granodiorite and granitic augen schist that underlie a 10 km^2 area in the southeastern corner of the map area. They are widespread in the adjoining areas to the

Figure 3

View southeastward from Costigan Mountain fire tower showing typical hilly topography in the area. GSC 188446

[1] Both the National Topographic map for Plaster Rock (east half) map area (21 J/14, E1/2) and the Canada Gazeteer use the name Costigan Mountains; however, locally this topographic feature is called Costigan Mountain, and furthermore, the New Brunswick Department of Lands and Mines 1 inch to 1/4 mile topographic map J-12, South Branch Gulquac River, names the feature Costigan Mountain, from which were derived the names Costigan Mountain Formation and Costigan Mountain fire tower. In this report the name Costigan Mountain will refer to the highest mountain (670 m) in the area.

east and south (Skinner, 1972, 1975; Poole, 1963), and also about 48 km to the northeast in the Big Bald Mountain and McKendrick Lake map areas (Anderson, 1970a, 1970b) where Fyffe et al. (1977) dated them. The whole-rock Rb-Sr isochron obtained gave an age of 479 ± 14 Ma and an initial $^{87}Sr/^{86}Rb$ ratio of 0.7030 ± 0.0060 using a half-life of 4.88×10^{10} years ($\lambda^{87}Rb = 1.42 \times 10^{-11} a^{-1}$). This age corresponds to Early Middle Ordovician based on the time scale of Armstrong (1978).

These rocks in the Plaster Rock (east half) map area are sheared and mylonitic near the Catamaran Fault which cuts across the southeastern corner of the map area. Their mineralogical composition is difficult to determine. Plagioclase (oligoclase to andesine), quartz and mica are prominent in most exposures, with potash feldspar prominent in some. Near the unconformity with rhyolitic rocks of the Costigan Mountain Formation (lDCva) micrographophyre is prominent in the matrix of the granites.

Lower Devonian

Intercalated westerly dipping basalt, slate and rhyolite of Early Devonian age underlie most of the map area. This assemblage has been traced over 110 km from Upper Kintore in the southwest (St. Peter, in preparation) to Serpentine River in the north (Irrinki, 1977a, b) and has been named the Tobique Group after the river along which it outcrops.

TABLE OF FORMATIONS

Era	Period (or Epoch)	Formation (thickness in metres)	Map Unit	Lithology
PALEOZOIC	Mississippian(?)	Arthurette Redbeds 60	MAcg	Red conglomerate, grit and sandstone
		Unconformity		
	Devonian		Dd	Green-grey diabase sills, dykes and stocks
		Intrusive contact		
	Lower Devonian	Tobique Group		
		Wapske Formation 8500 (not in stratigraphic order)	lDWvb 5300	Green-grey basalt, minor diabase sills and dykes, slate, greywacke and rhyolite
			lDWva 0-500	Pink and grey massive and laminated rhyolite, minor basalt, slate and diabase
			lDWs 3000	Grey slate, greywacke, shale, minor basalt and diabase sills and dykes, conglomerate and limestone
		Costigan Mountain Formation 3000 (not in stratigraphic order)	lDCva 750-2500	Pink, red and grey rhyolite, quartz-feldspar porphyry flows, tuffs, and pyroclastic breccias, minor shale, greywacke, basalt and diabase sills and dykes
			lDCs 0-300	Grey shale, argillite and greywacke, minor diabase, rhyolite and basalt
			lDCvb 0-1200	Green-grey basalt flows and tuffs, minor volcanogenic sediments and conglomerate
		Unconformity		
	Ordovician		Og	Grey to pink, cataclastic, massive and schistose biotite granite, granodiorite and granitic augen schist

Tobique Group

The Tobique Group comprises a lower unit, the Costigan Mountain Formation, and a conformably overlying unit, the Wapske Formation. These names and units, introduced by St. Peter (1978), will be used in this report. Within the map area each formation contains rhyolite, basalt and sediments. The Costigan Mountain Formation consists mainly of rhyolitic rocks and the Wapske Formation mainly of intercalated basalt, slate and greywacke.

Costigan Mountain Formation

The Costigan Mountain Formation is named after Costigan Mountains[1], the highest feature in the map area, which is located in the northeastern part of the area and which is underlain by the formation.

The Costigan Mountain Formation is exposed in a northerly trending belt up to 5 km wide along the east side of the map area and extends 9 km eastward into the Tuadook Lake map area (Skinner, 1975). The lower part of the formation is a basaltic unit in northern and southern Plaster Rock (east half) and Tuadook Lake map areas (unit 4a, Skinner, 1975). The upper unit of the formation is mainly rhyolitic rocks with intercalated shale, siltstone and basalt.

The thickness of the formation from its base in the Tuadook Lake map area to the base of the overlying Wapske Formation is about 3000 m, made up of 0-1200 m of the Basaltic unit, 750-2500 m of the Rhyolitic unit and 0-300 m of the intercalated Shale unit. These thicknesses are based on a section along Lake Branch Gulquac River where the dips of interbedded sediments average about 30 degrees southwest. However, strikes are variable, probably due to complex folds and faults because of variations in form and competency of the bodies (rhyolites, slates and siltstones) involved.

Lithology. A small area, 6.5 km^2, of the basal Basaltic unit (lDCvb) is present in the northeastern Plaster Rock (east half) map area and another about 0.4 km^2 along the southern edge. The major part of the formation comprises the Rhyolitic unit (lDCva), 120 km^2, which lies along the eastern side of the map area and encloses a small area, 2.6 km^2, of the Shale unit (lDCs) in the north. Two small stocks of diabase cut the Rhyolitic unit (lDCva) south of Stanley Mountain and Deer Mountain.

Basaltic Unit (lDCvb). The Basaltic unit underlies the Rhyolitic unit (lDCva) in the hilly northeastern corner of the map area and in the gently sloping terrain in the south. Outcrop is sparse; in the northeast, basaltic rocks are exposed only on the steep slopes and on the top of the highest hill. The rocks there are mainly green-grey, aphanitic, massive basalt. Some are amygdaloidal and contain epidote veinlets. One outcrop north of Twomile Brook contains reddish epidote-bearing, scoraceous basalt and 275 m farther north, rubble of quartz pebble conglomerate is present. The specific gravity of ten basalt specimens from the Basaltic unit ranged from 2.695 to 2.90 and averaged 2.80.

Microscopic examination of the basaltic rocks shows aphanitic to fine grained basaltic to diabasic textures and the chief constituents are plagioclase (labradorite and albite), in places altered to epidote; augite, commonly largely altered to actinolite and chlorite; and leucoxene, sphene, magnetite and iron sulphides. Vesicles are filled with chlorite, quartz and epidote. Epidote is also common in veinlets.

Rhyolitic Unit (lDCva). The Rhyolitic unit (lDCva) consists mainly of grey, pink, reddish orange and light green finely porphyritic, massive rhyolitic flows, quartz-feldspar porphyry, laminated flows and pyroclastic breccias and tuffs that are intercalated with lesser amounts of shale, greywacke and basalt. The best sequence is seen along Lake Branch Gulquac River.

Rhyolite is commonly finely porphyritic, red or grey and weathers pink or buff. The matrix is aphanitic, the feldspar phenocrysts are commonly euhedral, the quartz phenocrysts anhedral and both are about 2 mm long. The feldspar phenocrysts are red, pink or buff, and the quartz phenocrysts are clear or grey.

The porphyries are similar to the rhyolite but contain larger phenocrysts of quartz and/or feldspar, commonly from 2 to 5 mm in diameter. Quartz-feldspar porphyry occurs on the east sides of Deer, Stanley and Trail mountains and on the highway northwest of Stanely Mountain. Feldspar porphyry occurs on the south side of Raymond Mountain and on the logging road 1.5 to 3 km south of Trail Mountain.

In thin section quartz-feldspar porphyry is seen to be composed of glomeroporphyritic albite and corroded quartz phenocrysts in a microfelsic matrix. Biotite is commonly altered completely to chlorite. The phenocrysts in the porphyries at Deer and Stanley mountains are cataclastic. Some plagioclase in the feldspar porphyries is altered to montmorillonite (clay).

Laminated rhyolites are aphanitic, pink, red or grey rocks. The laminations are light and dark shades of similar colours, from 2 to 5 mm or more thick. They are common on Costigan Mountain, particularly on the ridge west of Falls Brook, along Lake Branch Gulquac River south of Costigan Mountain, on the highway 0.5 km from the western boundary of the formation, and on Stanley Mountain and 0.8 km northeast of Deer Mountain. Under the microscope the laminations are seen to be composed of devitrified glass, commonly containing scattered microphenocrysts of albite. The colour of the laminae depends upon the amount of hematite, quartz, biotite, chlorite and epidote present. The devitrified glass is generally spherulitic and the well developed spherulites are commonly brown from hematitic inclusions, but generally the spherulites are poorly developed and some of these are irregular-shaped quartz-feldspar aggregates up to 2 mm across. Commonly the laminae are separated by an axiolitic lamina about 0.15 mm thick. Some of the laminae are composed of hematite-stained globulites aligned in parallel layers. In places the laminae are planar, but generally they are highly contorted, apparently due to the viscous nature of the flow (Macdonald, 1972, p. 94).

Pyroclastic breccias have a greenish grey or buff aphanitic matrix that encloses pink, buff and/or grey angular rhyolitic clasts up to 0.6 m long but commonly between 6.5 and 15 cm long. The coarsest breccia seen is present on Lake Branch Gulquac River about 0.8 km from its mouth. The angular pink rhyolitic clasts have variable shapes and sizes and are enclosed in a greenish grey aphanitic matrix (Fig. 4). Similar, less coarse breccias are present on Gulquac River about 2.5 km above Lake Branch; along Highway 108, 0.5 km east of the western boundary of the Rhyolitic unit (lDCva); and at the junction of the south-branching logging road.

Lapilli tuffs are similar to the pyroclastic breccias except the clasts are less than 6.5 cm long. These tuffs occur on Gulquac River about 200 m west of the northerly branching logging road on the east side of the map area and on Wapskehegan River south and west of Deer Mountain.

The pyroclastic nature of these rocks was not recognized until thin sections were examined and shards and pumice fragments were identified in the matrices. Greenish grey laminated tuffs 1.1 km west of Beaver Lake in the southeastern part of the map area were identified as greywackes or possible volcanics in the field and confirmed as tuffs under the microscope. These contain 5 to 10 per cent pyrrhotite.

[1] see footnote page 4

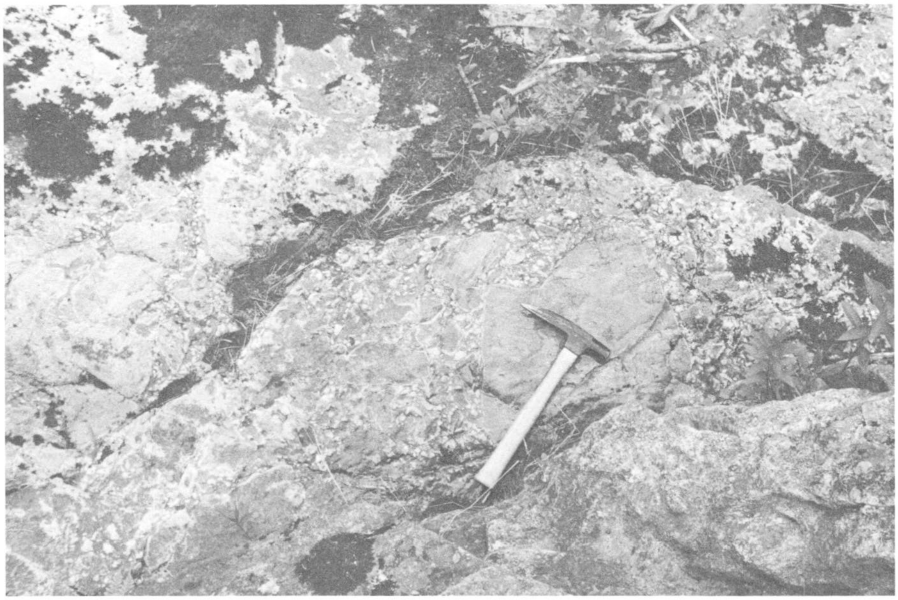

Figure 4

Pyroclastic breccia in Rhyolitic unit, Costigan Mountain Formation on Lake Branch Gulquac River, 0.8 km from the mouth. GSC 188479

The composition of these rhyolitic rocks is impossible to determine without chemical analyses because of the aphanitic to glassy nature of their matrices. However the mineralogy of the phenocrysts (albite, minor potash feldspar and quartz), common microfelsic nature of the matrices, low colour indices (between 10 and 30) and specific gravity (range 2.51 to 2.69, averaging 2.55 for a total of 80 specimens) strongly suggest a rhyolitic composition.

Basalt occurs sparsely within the Rhyolitic unit and was noted along Lake Branch Gulquac River, Gulquac River, the south side of Trail Mountain, south and west of Raymond Mountain and south and west of Beaver Lake.

Shale Unit (1DCs). The Shale unit (1DCs) occurs as three relatively small northwesterly trending lens-shaped bodies underlying about 2.5 km^2 within the Rhyolitic unit (1DCva) south of Costigan Mountain in the northeastern part of the map area. The unit is exposed mainly along Lake Branch Gulquac River and in three outcrops along Falls Brook.

The Shale unit consists of shale, argillite and greywacke and includes diabase sills and dykes and minor rhyolite and basalt. The shale and argillite are dark grey and the greywacke is light grey; some of the shale is distinctly laminated and some is massive, structureless argillite, particularly near diabase. The shale within the largest lens is fossiliferous (see below). Identical shale occurs as thin intercalations within the Rhyolitic unit in lenses too small to show on the map.

Age. The age of the Costigan Mountain Formation is based on dating by A.J. Boucot, Oregon State University, of brachiopods collected by the author in 1970 and by R.R. Irrinki in 1975 from the largest of the three lenses of the Shale unit (1DCs).

GSC loc. 87017. Roadcut in grey laminated silty shale and massive argillite, east side of Falls Brook 1 km south-southwest of the top of Costigan Mountain.

Coelospira

Spinoplasia sp.

Leptaena "rhomboidalis"

Anoplia with three sets of spines along hinge (unusual shell) pterineoid pelecypod

Boucot (pers. comm., 1972) stated that the collection is of Early Devonian, probable Gedinnian age. Trilobites were also collected from this location and identified by W.T. Dean, Geological Survey of Canada (personal communication, 1973).

Dalamites

Otarian

indeterminate calymenid pygidium

fragment of indeterminate homalonotid thorax

Dean stated that these are also known from Silurian strata and do not offer any conclusive evidence of a Devonian age.

GSC loc. 93096. Same location as GSC loc. 87017 above.

Leptaena "rhomboidalis"

Craniops

Coelospira sp.

Salopina? sp.

GSC loc. 93098. 120 m northeast of 93096.

Pacificocoelia? sp.

Boucot (personal communication to R.R. Irrinki, 1976) stated that the collections are of Early Devonian, possibly Helderbergian age and belong to benthic assemblage 3; quiet water.

GSC loc. 87022. River bank in grey shale, south side of Lake Branch Gulquac River 1 km west of the eastern boundary of the map area.

Coelospira

dalmanellid

orthotetacian

rostrospiroid(?)

Boucot (personal communication 1972) stated that the collection is probably Early Devonian.

Samples of tuff, rhyolite and quartz-feldspar porphyry of the Costigan Mountain Formation, Rhyolitic unit (1DCva) collected within the map area, have yielded an 8-point whole-rock Rb-Sr errorchron of 409 ± 35 Ma with MSWD (mean square of weighted deviates) of 3.46 and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7052 ± 0.006 calculated with a rubidium decay constant of $1.42 \times 10^{-11} a^{-1}$ (Fyffe and Cormier, 1979). This age centres on Early Devonian of the time scale of Armstrong (1978).

Wapske Formation

The Wapske Formation is defined by St. Peter (1978) as the interfingering assemblage of mafic volcanic rocks (basalts), sedimentary rocks and minor felsic volcanic rocks that overlie the Costigan Mountain Formation. The contact between the Costigan Mountain and Wapske formations is at the top of the rhyolitic rocks of the Costigan Mountain Formation. Lithologies are similar in both formations but the proportions differ. Basalt and sediments predominate in the Wapske Formation and rhyolite predominates in the Costigan Mountain Formation, and furthermore the sedimentary rocks in the Costigan Mountain Formation lack cleavage while those in the Wapske Formation have a cleavage.

The Wapske Formation underlies all of the map area west of the Costigan Mountain Formation with the exception of the western part which is underlain by flat-lying Mississippian(?) Arthurette Redbeds. The best exposed section is along Wapskehegan River and its main tributary, River de Chute. Good exposures and a relatively good section also can be seen along Gulquac River. The Wapskehegan River is known locally as the Wapske, the name given the formation.

The thickness of the formation, based on the diagrammatic cross-section along Wapskehegan River, is about 8500 m made up of about 5300 m of the Basaltic unit, 3000 m of the Sedimentary unit and from 0-500 m of the Rhyolitic unit.

Lithology. The Wapske Formation is subdivided into three lithological units or assemblages that interfinger with one another and have no stratigraphic significance; they are the Basaltic unit (lDWvb), the Sedimentary unit (lDWs), and the Rhyolitic unit (lDWva). In the central part of the map area between Wapskehegan and Gulquac rivers, the Basaltic unit predominates. North of Gulquac River the Basalt and Sedimentary units are about equally represented. The Rhyolitic unit underlies a wedge-shaped area 2 km wide along North Gulquac River at the northern boundary of the map area, and a lens-shaped area in the northwestern corner of the map area. South of the Wapskehegan River the Sedimentary unit predominates in the western part of the area and the Basaltic unit in the central part, and the Rhyolitic unit lies within the other units and underlies relatively narrow (760 m or less) lens-shaped areas near and southwest of Armstrong Mountain and east of Edgar Brook. Diabase sills and dykes and a stock intrude both the Basaltic and sedimentary units and are particularly prominent in the central part of the map area.

Basaltic Unit (lDWvb). The Basaltic unit (lDWvb) consists mainly of basalt flows interlayered with lesser amounts of slate, greywacke, conglomerate and rhyolite, and includes diabase sills and dykes. The intercalated sedimentary and rhyolitic rocks are similar to those in the Sedimentary and Rhyolitic units.

Basalt is commonly greenish grey, fine grained, massive and breaks into blocks. Some is medium grained, diabasic and massive and may form sills and/or dykes. The finer grained varieties are commonly amygdaloidal and in places are pillowed.

Microscopic examination of the basalt shows that the original basaltic or diabasic textures are preserved. The chief constituents are plagioclase, clinopyroxene and chlorite. Most also contain calcite, sphene and/or leucoxene, some contain epidote or clinozoisite and ilmenite, and a few contain sericite, prehnite and/or pumpellyite. The plagioclase is commonly albite, but some is labradorite, andesine or oligoclase, commonly zoned; some plagioclase is highly altered to epidote, clinozoisite, sericite, prehnite and/or pumpellyite. Clinopyroxene, although not always present, is commonly fresh and occurs as grains ranging from 1 cm (ophitic) to 0.1 mm or less; some is partly altered to chlorite and calcite and some has been completely altered to these minerals. Chlorite is widespread interstitially and/or fills vesicules. Some vesicules are also filled with combinations of chlorite, calcite, quartz, epidote, albite and in places with prehnite and/or pumpellyite.

A typical section of the Basaltic unit is present on Gulquac River 2.8 km west of Lombard Brook where the exposures are relatively good, although not extensive enough to be sure that some of the massive basalt is flow, sill or dyke. The Basaltic unit tongue is about 360 m thick, trends northwest and dips about 60 degrees southwesterly and consists of:

	Metres	
Top		Greywacke and slate of Sedimentary unit (lDWs)
	120	Basalt flow?, massive, fine to medium grained
	50	Greywacke, laminated and graded, tops southwest
	5	Basalt flows, pillowed, tops southwest
	45	Greywacke and minor basalt
	65	No outcrop
	10	Diabase sill?, massive, medium grained
	2.5	Basalt flow, massive, fine grained
	1.2	Conglomerate, poorly sorted, loosely packed, rounded clasts to 2 cm of vein quartz, chert, basalt, rhyolite and greywacke in a limy greywacke matrix
	6	Basalt flow, massive, fine grained
	1.5	Basalt flow, massive, medium grained, diabasic, vesicular top
Bottom		Greywacke and slate of Sedimentary unit (lDWs)

A low northerly trending ridge in the western part of the map area between the highway and Gulquac River is shown as probably being an inlier of the Basaltic unit (lDWvb?) surrounded by flat-lying Arthurette Redbeds because the ridge is similar topographically to the one a kilometre to the west which is clearly a Basaltic unit (lDWvb) inlier.

Pillow lavas are not plentiful in the map area. Commonly the pillows are round in cross-section and about 0.6 m in diameter as on Gulquac River about 3.2 km west of Lombard Brook, and in three outcrops about 3.5 km east of the western boundary of the map area along Gulquac River and the nearby road (Fig. 5). Pillows are also present on Wapskehegan River 5 km east of the western boundary and on Oven Rock Brook where they are up to 1.5 m by 4.5 m in cross-section; there the basalts are interbedded with greywacke and slate. Tops at all these localities are to the west. Pillows are present on River de Chute in large blocks of basalt talus at the "U" bend 2.5 km southeast of Armstrong Mountain and are poorly developed in an outcrop 0.7 km below the "U" bend.

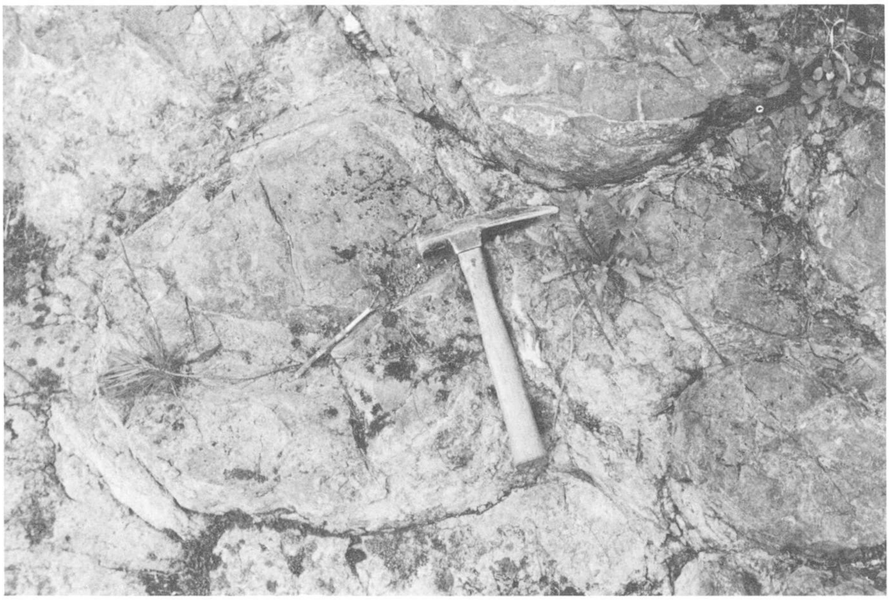

Figure 5

Pillows in basalt in Basaltic unit, Wapske Formation on Gulquac River, 3.5 km east of western boundary of map area. GSC 188556

Figure 6

Hyaloclastite in Basaltic unit, Wapske Formation on Gulquac River, 2.5 km west of Lombard Brook. Irregular light coloured fragments are highly amygdaloidal metabasalt. GSC 188483

Tuffaceous-like basalt (hyaloclastite) is present in two places on Gulquac River: on a sharp bend 2.5 km east of the west border of the map (at shearing symbol), and in two outcrops 20 m apart about 1.3 km west of Lombard Brook where the river takes a sharp bend to the north, and in the southern part of the area on a small hill 2 km north of Beaver Brook at longitude 67°06'W.

The hyaloclastite is commonly light greyish green and speckled with white or pink feldspar and in places with calcite amygdules, and it is massive to slightly schistose and has a hackly fracture surface. These rocks were formed by the extrusion of basalt under water and its consequent granulation or shattering into small glassy flat plates or angular fragments (Macdonald, 1972) and their tuffaceous nature became evident only after they were examined in thin section. They contain altered glomeroporphyritic and broken plagioclase phenocrysts in a matrix of brown and light green recrystallized glass fragments with irregular diffuse boundaries that in places are outlined by grains of sphene or leucoxene. Many of the glassy fragments appear to have been pliable during and/or after being deposited. They contain small plagioclase phenocrysts and microlites and epidote grains and are highly vesicular with fillings of chlorite, quartz, epidote, orthoclase and calcite.

The thickness of the hyaloclastite near the western boundary of the map area is not known. It underlies pillow lava that outcrops in a roadcut 120 m to the northwest. The hyaloclastite on Gulquac River west of Lombard Brook may be up to 300 m thick based on hand specimen identification from an outcrop and two rubble piles that occur along a 300-m part of the river upstream from the two outcrops identified as hyaloclastite. The upper part of the hyaloclastite contains irregular fragments of cream-weathering, highly amygdaloidal (albite, epidote, chlorite) basalt (Fig. 6).

These hyaloclastite occurrences may have a similar origin to the palagonite tuff at the base of the Lower Devonian Dalhousie Group at Dalhousie, New Brunswick (Alcock, 1935; Mossman and Bachinski, 1972). The Plaster Rock deposits, however, unlike the Dalhousie deposits are not well bedded or friable.

Figure 7. Peperite in Basaltic unit, Wapske Formation on Wapskehegan River, 1.6 km southeast of Ryans Brook. Clasts of amygdaloidal metabasalt are embedded in a slaty matrix. GSC 188546

St. Peter (1978) identified hyaloclastite 1 km south of Sadler Mountain and in an outcrop 2.5 km west of River de Chute Forks at a point 1.3 km north of Wapskehegan River. His description, however, resembles the peperite deposit described below.

An agglomeratic-looking basalt-slate mélange (peperite) a few metres thick is present within a basalt lens about 300 m thick on the Wapskehegan River 1.6 km southeast of Ryans Brook. The agglomeratic horizon overlies 50+ m of massive basalt and is overlain by a few metres of rusty, pyrrhotite-bearing, aphanitic, grey, massive, chert-bearing, vesicular basalt overlain by 150+ m of massive basalt. The agglomeratic rock consists of light grey weathering, rounded and angular clasts up to 20 cm or more across of dark grey amygdaloidal (calcite) basalt enclosed in a grey slaty matrix (Fig. 7). Many of the basalt clasts have unchilled margins, whereas others are chilled and contain variolitic borders. The slate matrix contains angular fragments of quartz to 0.5 mm, feldspar to 3 mm, calcite to 5 mm and chloritized glass to 5 mm or more, as well as minute fragments of basalt.

The origin of these agglomeratic rocks is related to that of hyaloclastites in that they both form by decrepitation and thermal shattering of magma in contact with water. The agglomeratic type formed by the intrusion of basalt into water-soaked muds and were called "peperites" by Scope in 1827 (Williams and McBirney, 1979).

Rhyolite occurs as one or more thin flows, dykes or sills intercalated with basalt of the Basaltic unit: on Gulquac River, (a) immediately west of the map area, (b) 1.8 km east of the western boundary, (c) at the logging road bridge, and (d) 0.5 km above the bridge; on Wapskehegan River 3.4 km from the western boundary; and on River de Chute: (a) southwest of Armstrong Mountain, and (b) below Raymond Brook.

Sedimentary Unit (1DWs). The Sedimentary unit (1DWs) consists of interbedded slate, greywacke, shale and minor basalt, diabase, conglomerate and limestone. The unit is intercalated with the Basaltic unit (1DWvb) and to a limited extent with the Rhyolitic unit (1DWva). It underlies a northerly trending belt about 15 km wide in the southwestern part of the map area, 10 km wide at the centre of the map area, and 8 km wide at the centre of the northern boundary. Much of this belt contains large lens-shaped bodies or tongues of the Basaltic unit (1DWvb) and four smaller lens-shaped bodies of the Rhyolitic unit (1DWva).

Slate and silty slate make up most of the Sedimentary unit (1DWs) particularly in the southwest. Elsewhere, greywacke is commonly interbedded with slate and is prominent along Gulquac River about 2.5 km west of Lombard Brook, along the lower part of Sadler Brook, along Wapskehegan River for about 5 km above and 3 km below River de Chute Forks and River de Chute for about 5 km above the Forks.

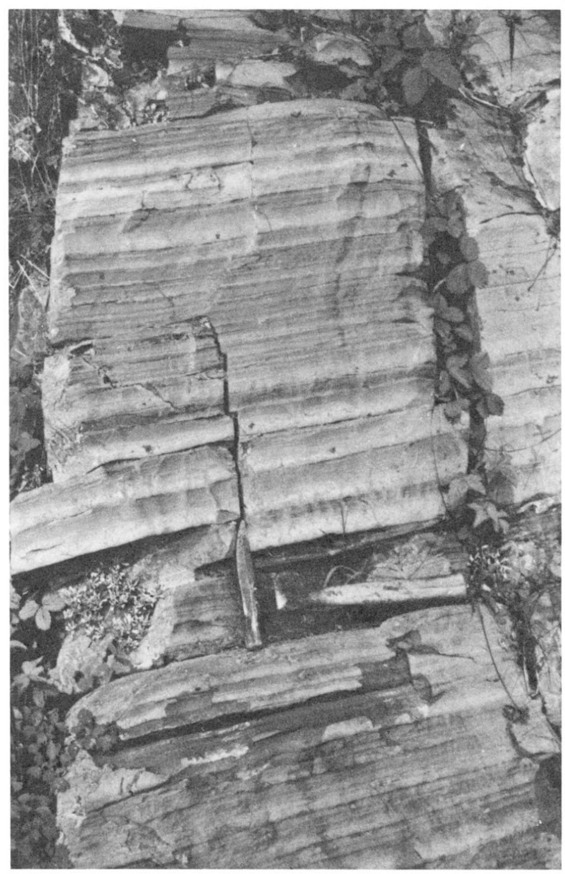

Figure 8. Thin bedded greywacke of Sedimentary unit, Wapske Formation on Wapskehegan River, 0.8 km below River de Chute Forks. Note graded bedding well displayed on weathered surface. GSC 188457

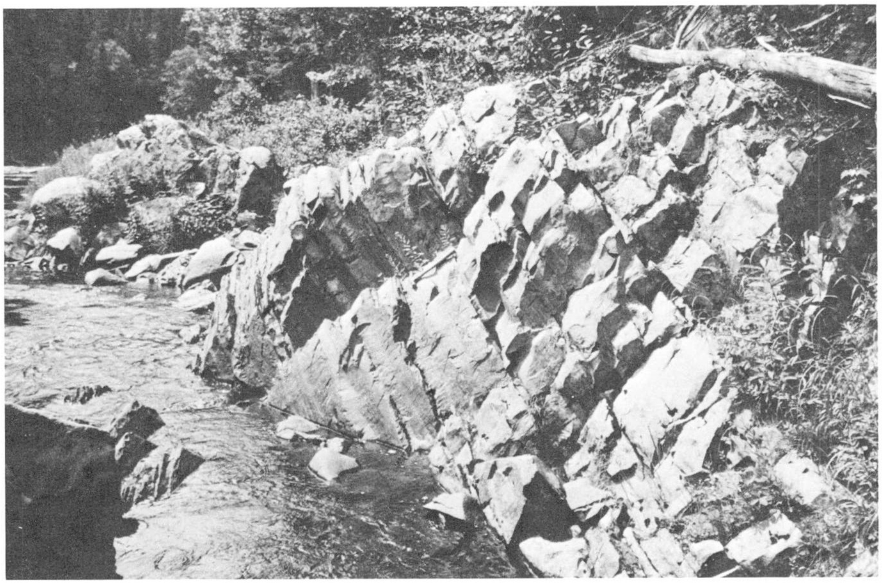

Figure 9

Thick, massive greywacke beds of Sedimentary unit, Wapske Formation, adjacent to beds in Plate 6, on Wapskehegan River, 0.8 km below River de Chute Forks. Note hammer in centre of photograph for scale (33 cm long). GSC 188460

Generally the slate is dark grey and the greywacke light grey. The silty slate and shale are commonly parallel laminated and the greywacke graded. Graded greywacke beds are particularly distinctive on weathered surfaces since the colour also grades from light grey in the coarser material at the base of the bed to darker grey in the finer shaly or slaty material at the top of the bed. Commonly the greywacke is limy and occurs as repeated graded beds 1 to 5 cm thick, but in places the beds are more massive and up to 0.3 m or more thick (Fig. 8, 9). The greywacke is composed of angular quartz, feldspar and rock grains up to 0.25 mm long in a microcrystalline matrix composed of quartz, feldspar, sericite, chlorite and commonly, calcite. In places sphene, leucoxene, clinozoisite, hematite, magnetite and pyrite grains are present. The plagioclase is albite and accounts for about 10 per cent of the grains. The rock particles are difficult to identify because of the fineness of grain size, but appear to be quartzite, slate and rhyolite and seem to account for only 5 per cent or less of the grains. The matrix makes up about 40 to 50 per cent of the rock.

The greywacke was mapped as siltstone, but petrographic study indicated that although much of the material is of silt size (to 0.06 mm) most beds contain fine grained, sand-sized grains and up to 50 per cent shaly matrix. The greywackes display most, if not all, of the divisions of the Bouma model (Pettijohn, 1975; Walker, 1976). A cursory investigation of twelve of the coarser greywacke beds sampled along River de Chute and Wapskehegan River below the Forks showed that three quarters contained the A cycle (graded bedding at the base) indicating rapid deposition; half contained the B cycle (horizontal laminations) formed by traction in the upper (current velocity) flow regime; half contained the C cycle (ripple crosslaminated fine sandstone) in the lower flow regime; none contained the D cycle (indistinctly laminated silty pelitic material); and nearly all contained the uppermost E cycle (pelitic interval – shale or slate).

Limestone occurs only as a 30 cm-thick lens intercalated with slate on Wapskehegan River about 0.5 km above River de Chute Fork.

Polymictic pebble conglomerate is interbedded with slate and greywacke on Dingee Brook 8 km east of the western boundary of the map area and on Wapskehegan River 5 km east of the western boundary, where conglomerate beds up to 0.6 m thick are intercalated with coarse sandstone over a zone about 3 m thick. The clasts are rounded and range in size up to 15 cm in diameter, but generally are less than 5 cm in diameter, are composed of vein quartz, rhyolite, basalt, greywacke and slate and are set in a limy, greywacke matrix (Fig. 10). The conglomerate at these localities is similar to that which occurs in the Basaltic unit (lDWvb) on Gulquac River 2.8 km west of Lombard Brook. The Dingee Brook and Gulquac occurrences are probably from the same stratigraphic horizon.

Basalt within the Sedimentary unit (lDWs) is similar to that in the Basaltic unit (lDWvb) and occurs in flows or sills a few metres to several tens of metres thick. There may be much more basalt and possibly rhyolite in the interstream areas than is shown on the map.

Rhyolitic Unit (lDWva). The Rhyolitic unit of the Wapske Formation (lDWva) consists of mainly rhyolite with intercalated basalt flows and minor slate, and diabase dykes and sills. The rhyolite is lithologically similar to the rhyolite in the Costigan Mountain Formation. The unit occurs as six lens-shaped bodies mainly within the Sedimentary unit (lDWs).

The thickest lens outcrops along North Gulquac River over a distance of 2 km where the rhyolite is pink, grey and buff and commonly aphanitic and fractured and is intercalated with basalt flows and cut by diabase dykes. Rhyolite also outcrops on the highest hill south of the river.

The most prominent of the rhyolitic lenses underlies a discontinuous ridge southwest of Armstrong Mountain. It is up to 750 m wide and is 8 km long extending southwestward from River de Chute where it is 55 m wide and composed of reddish brown rhyolite breccia. Elsewhere it outcrops on the steep hillsides and is mainly pink, massive and aphanitic; some is laminated. A small rhyolitic lens 550 m wide and 2.5 km long lies directly to the east and underlies the hills between the head of Lindsay Brook and North Branch Southwest Miramichi River. This body probably is a tongue off the main body.

A small rhyolite lens about 600 m wide and 3 km long lies within the Basaltic unit (lDWvb) and underlies the prominent hill between Edgar Brook and River de Chute. Massive pink porphyritic rhyolite outcrops over a distance of about 150 m along the river and on the south slope of the hill to the southwest.

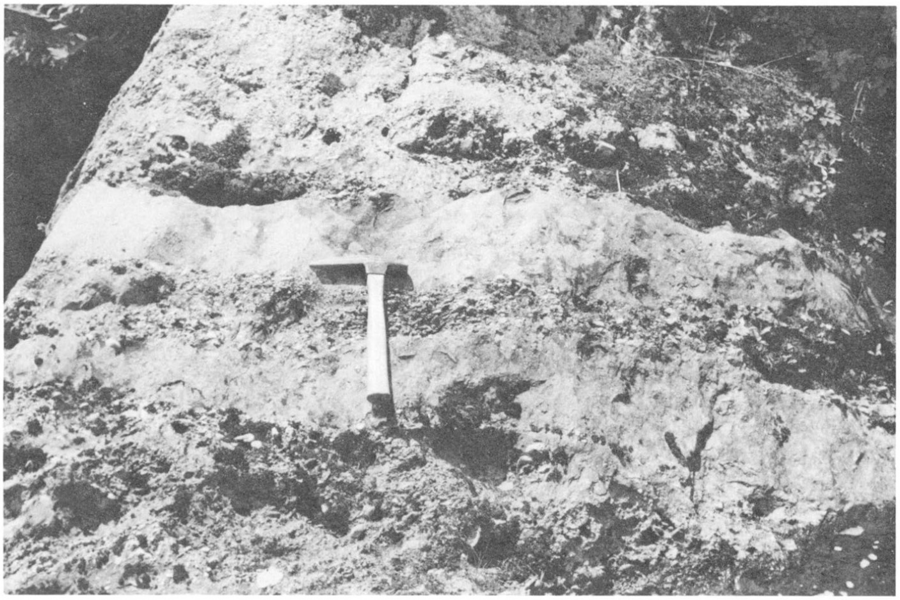

Figure 10

Polymictic conglomerate of Sedimentary unit, Wapske Formation, on Wapskehegan River, 5 km east of western boundary of map area. GSC 188545

A prominent northeasterly trending ridge in the northwestern corner of the map area is shown as probably being underlain by the Rhyolitic Unit (lDWva?) because it lines up with an outcrop of rhyolite on Gulquac River immediately west of the map area, and furthermore, the most prominent ridges in the area are underlain by rhyolite.

Age and Correlation. The age of the Wapske Formation is based on dating by A.J. Boucot, Oregon State University, of brachiopods collected from four locations within the Sedimentary unit (lDWs), each about 1500 m above the base of the formation. The first two collections were made by R.R. Irrinki (1977c) in 1975 along the main logging road north of Gulquac River and about 3 km south of the northern boundary of the map area. The second two collections were made by St. Peter in 1976 along River de Chute south of Armstrong Mountain.

GSC loc. 93119. On main logging road north of Gulquac River 5.4 km east of bridge across Gulquac River.

Leptaena "rhomboidalis"

Platyorthis? sp.

Concinnispirifer? sp.

Nucleospira sp.

orthotetacid

Coelospira sp.

GSC loc. 93120. On main logging road north of Gulquac River, 0.5 km east of GSC loc. 93119.

Discomyorthis

Howellella? sp.

Leptaena "rhomboidalis"

Eatonia

Boucot (personal communication to R.R. Irrinki, 1977) stated that these two collections are of Helderbergian age, probably New Scotland or younger, that they are a benthic assemblage 3; moderately high diversity community; quiet water and could be a Dalhousie Formation equivalent.

GSC loc. 93733. In dark grey calcareous greywacke bed 1 m thick in stream bed at River de Chute south of Armstrong Mountain.

Leptostrophia or **Protoleptostrophia**

Eatonia? sp.

bryozoan

pelmatozoan columnals

Boucot (personal communication to C. St. Peter, 1977) stated that the collection is Lower Devonian, and if the **Eatonia** is correctly identified a Helderbergian age is probable.

GSC loc. 94732. In gritty, volcanoclastic greywacke on logging road south side of River de Chute, 600 m southeast of GSC loc. 94733.

Coelospira of Devonian type

Leptaena "rhomboidalis"

dalmanellid

leptocoelid?

leptostrophid

Meristella sp.

stropheodontid

tetracoral

Boucot (personal communication to C. St. Peter, 1977) stated that the collection is Lower Devonian, and he suspected that a Helderbergian age is most likely.

The Wapske Formation correlates paleontologically with lithologically similar rocks of the Dalhousie Group in northern New Brunswick in the Dalhousie map area (Alcock, 1935), Charlo-Pointe Verte map areas (Greiner, 1960, 1970), Upsalquitch Forks map area (Potter, 1965) and Tetagouche Lakes-Bathurst map areas (Skinner, 1974). According to St. Peter (1978) the Wapske Formation also correlates with the Dockendorff Group in the Presque Isle area of northeastern Maine (Boucot et al., 1964).

Interpreted ages of the fossils in the Costigan Mountain and Wapske Formations are the same, i.e. Early Devonian, probably Helderbergian and possibly New Scotland (Gedinnian). Although the Wapske, rich in sediments and mafic volcanics, conformably overlies the Costigan Mountain, rich in acid volcanics, it is quite possible that the Wapske is a lateral facies equivalent of the upper part of the Costigan Mountain Formation.

Environment of Deposition

The depositional environment of the Tobique Group probably varied between subareal and shallow water marine. Subareal conditions are suggested by scoriaceous tops to a few basalt flows in the Costigan Mountain Formation, while shallow marine conditions are suggested by fossils of benthic assemblage 3, in quiet water. Conglomerates, graded bedding, and pillow basalts, each in itself, have little depth connotations. Boucot (1975) described the benthic assemblage 3 as the upper part of the subtidal zone, probably in water no deeper than 60 m.

Directions of paleocurrent flow are too few to make firm conclusions, other than to suggest that current flow toward the south-southwest predominates over that to the northeast. Seven paleocurrent directions were interpreted from current bedding structures in greywacke beds in the Sedimentary unit of the Wapske Formation. Along Wapskehegan River up to 2 km below River de Chute Forks two beds indicated paleocurrents toward the northeast and two others indicated the currents toward southwest. Along River de Chute up to 1 km above Armstrong Mountain all three current beds indicated paleocurrents toward the south-southwest.

Devonian (Dd)

Diabase (Dd) occurs as lens-shaped sills and dykes up to about 600+ m thick and as stocks up to 1.4 km across, exposed mainly along Wapskehegan River and River de Chute and as thinner sills and dykes (d) along Gulquac River, Highway 108 and Beaver Brook. Diabase occurs within each of the Tobique Group formations, and is easily seen as sills and dykes in slates of the Sedimentary unit of the Wapske Formation (lDws) or in intercalated slates and shales within the volcanic units (lDCva, lDCvb, lDWvb).

Commonly it is impossible to determine whether or not the coarser, massive varieties of basalt are intrusives or flows because contacts are rarely exposed. Most coarser, massive basalts have been mapped as diabase (Dd, d) and appear to be sills. The diabase is a greenish grey, medium grained, massive, diabasic to ophitic rock composed of labradorite, andesine and/or albite, augite, chlorite and minor sphene and/or leucoxene, clinozoisite and ilmenite.

Six bodies of diabase (Dd) are outlined on the map, three appear to be sills and three stocks. The most westerly mapped sill (west of Ryans Brook) may be the largest, underlying about 3.5 km^2, while the others, with the exception of the small stock southwest of Stanley Mountain, underlie about 1.8 km^2 each. The stock west of Sadler Brook, the small stock southeast of Stanley Mountain and the stock southeast of Deer Mountain were mapped by St. Peter (1978). The last stock has been extended northwestward to the river where two outcrops of green-grey, medium grained, massive diabase were mapped by the writer's party.

Armstrong Mountain is shown on the map as being probably underlain by diabase (Dd?) because the highest magnetic anomaly in the map area (3580 gammas on GSC map 144G) overlies the mountain and outcrops of diabase to the southwest along River de Chute. Furthermore, diabase outcrops along strike northeast of the mountain along Wapskehegan River. St. Peter (1978) showed the mountain to be underlain by rhyolite based on three probable outcrops east of the top of the mountain. Rhyolite bodies commonly do not produce magnetic anomalies.

Mississippian(?)

Arthurette Redbeds (MAcg)

Flat-lying Mississippian(?) conglomerate and sandstone underlie much of the western part of the map area. These redbeds extend west of the map area about 25 km and are the lowermost of a 650 m thick Carboniferous sequence that occupies the 800 km^2 Plaster Rock Basin (Hamilton, 1965). According to Rose (1936) from base to top the sequence consists of 150 to 300 m of red conglomerate, sandstone and shale; about 40 m of limy shale and limestone; about 30 m of gypsum-bearing shale (which outcrops at Plaster Rock) and about 240 m of red friable shale capped by 8 m of conglomerate.

St. Peter (1979) mapped the area to the west as far as Plaster Rock and to the south of there for 22 km (Fig. 1), and has subdivided and named the Mississippian(?) rocks from the base upward: Gladwin Basalt, 30 m of columnar basalt, minor lithic arenite; Arthurette Redbeds, consisting of (a) 430 m of red polymictic conglomerate, sandstone and minor red mudstone, overlain by (b) 120 m of grey calcareous quartz pebble conglomerate, calcareous quartzose sandstone; and Plaster Rock Formation (150-300 m) consisting of red shale, shaly and nodular limestone, overlain by red and green shale, gypsiferous shale, and gypsum. Fossils have not been found anywhere in the sequence. The name Arthurette Redbeds will be used in this report to conform with St. Peter's (1979) work.

Only the lowermost 60 m or less of the Arthurette Redbeds underlies the map area and is exposed in only a dozen or more places along Gulquac and Wapskehegan rivers and in two places along the main logging road north of Highway 108. All of the outcrops seen comprise pale red conglomerate, commonly interbedded with pale red grit, sandstone and rarely siltstone. These red rocks are commonly mottled with cream to light green patches, lenses, or beds 2 cm or less thick. Some of these rocks are limy. The clasts are mainly rounded quartz, basalt, diabase, rhyolite, chert, greywacke, shale, quartz-feldspar-biotite gneiss and granite, commonly 2.5 to 5 cm across and rarely up to 0.6 m across.

The depositional environment of the Arthurette Redbeds in the Plaster Rock east half map area has been tentatively ascribed to subariel braided stream deposition by St. Peter (1979) based on the presence of planar and trough crossbeds in the sandstones and conglomerates, the variable nature of these rocks, and the lack of mudstone in the sequence.

Previous workers (Rose, 1936; Sund, 1958; Hamilton, 1965; and Webb and Kingston, 1975) lithologically correlated the Plaster Rock Basin rocks with the Mississippian Moncton and Windsor groups of southern New Brunswick. St. Peter (1979), however, concluded that the lithological correlations are not convincing although he believed that the Plaster Rock Basin sediments may be correlated with the Mississippian Horton and Windsor groups on paleoclimatic evidence as suggested by van de Poll (1978).

STRUCTURE

There are three structural domains in the Plaster Rock (east half) map area: (1) the cataclastically deformed Ordovician granitic rocks in the southeastern corner of the map area; (2) the less deformed Lower Devonian volcanic and sedimentary rocks of the Tobique Group that underlie most of the area; and (3) the flatlying Mississippian(?) Arthurette Redbeds of the Plaster Rock Basin in the northwestern part of the area. Domains (2) and (3) are separated by a pronounced angular unconformity and domains (1) and (2) are probably separated by a major unconformity. This latter observation is based on evidence observed 16 km to the southwest in the Juniper map area (Skinner, 1972) where a conglomerate containing granite clasts up to 45 cm in diameter overlies the granite basement. Furthermore, there is a great difference in intensity and style of deformation and in age between rocks of the two domains.

Domain (1)

Ordovician granitic rocks (Og) in the southeastern corner of the map area are cataclastic with a rude north to northeasterly shear and/or foliation. Little else is known about their structure except that they are cut by the southwesterly trending Catamaran Fault and several northeast-trending subsidiary faults outlined by topographic lineaments and mylonitic zones. The Catamaran Fault trends westerly across the southern part of the McKendrick Lake (Anderson, 1970b) and Tuadook Lake (Skinner, 1975) map areas into the southeastern corner of the Plaster Rock map area and then swings southwesterly within Juniper map area (Skinner, 1972). Anderson (1972) analyzed fracture patterns in intrusive and metamorphic rocks along 100 km of the Catamaran Fault and concluded that the faulting was in response to a northwest-southeast trending compressional stress and that the latest movement was right-lateral strike-slip of about 7 to 16 km.

Domain (2)

The Lower Devonian Tobique Group strata within the map area, for the most part, dip and face westerly at about 45 degrees and are cut by a cleavage whose strike parallels bedding and whose dip averages about vertical. This homocline is part of the east limb of a major syncline or synclinorium whose axis lies west of the map area, that is, the Chaleur Bay Synclinorium of St. Peter (1978).

Lower Devonian Wapske Formation greywackes and silty slates of the Sedimentary unit (lDWs) are well bedded and commonly distinctly graded so that top determinations are easily made (Fig. 8). Slaty cleavage is well developed in the slates of the Sedimentary unit of the Wapske Formation (lDWs) (Fig. 11) but not in the Shale unit of the Costigan Mountain Formation (lDCs).

Volcanic rocks are commonly massive, and consequently their structure cannot be determined except from associated sedimentary rocks as in the Rhyolitic unit of the Costigan Mountain Formation (lDCva) along Lake Branch Gulquac River, and in the Basaltic unit of the Wapske Formation (lDWvb) along Gulquac River. The attitudes of the associated sedimentary rocks in each case more or less parallel the attitudes of adjacent sedimentary rocks in the Sedimentary unit of the Wapske Formation (lDWs) indicating that the Costigan and Wapske Formations are conformable.

Laminations in the rhyolite in the Costigan Mountain and Stanley Mountain areas are spectacular but are highly variable within a small area and seem only to express the irregular deposition surface and/or the viscous nature of the lava. Pillows in the basalts are rare and not well exposed, and consequently are of little help in determining the structure.

Large parasitic folds were mapped in the Sedimentary unit of Wapske Formation (lDWs) near the contact with Costigan Mountain Formation, where less competent sediments and basalts overlie the more competent rhyolite of the Costigan Mountain Formation. Two open, upright synclines with wavelengths of about 700 m and southward plunge of about 15 degrees are present along Wapskehegan River west of Deer Mountain, and two open, upright anticlines with wavelengths of about 400 m and southwestward plunge of about 15 degrees are present on River de Chute above Raymond Brook. Two smaller, open, upright anticlines in limy greywacke occur on River de Chute about 1 km above River de Chute Forks. They have wavelengths of about 20 m and amplitude of about 10 m and plunge southwestward at about 10 degrees.

Numerous minor faults were observed in the Tobique Group rocks but because of the limited exposure little is known about their extent. One of the best examples of minor faults in the area is present on Gulquac River at the logging road bridge where a new roadcut through red-stained, vesicular basalt and massive basalt or diabase exposed a northeasterly trending fault that dips southeasterly 15 to 20 degrees and contains 0.3 to 0.6 m of gouge.

Domain (3)

Mississippian(?) Arthurette Redbeds within the Plaster Rock (east half) map area are undisturbed and commonly dip 5 to 10 degrees to the west. No folds or faults were observed.

METAMORPHISM

Three grades of metamorphism are present in the Plaster Rock (east half) map area. The Ordovician cataclastic granitic rocks (Og) have been metamorphosed to medium grade (amphibolite facies) as indicated by the presence of amphibolite in these rocks in the Tuadook Lake map area 0.8 km to the east of the boundary. Metamorphism in the Costigan Mountain Formation is low grade (greenschist

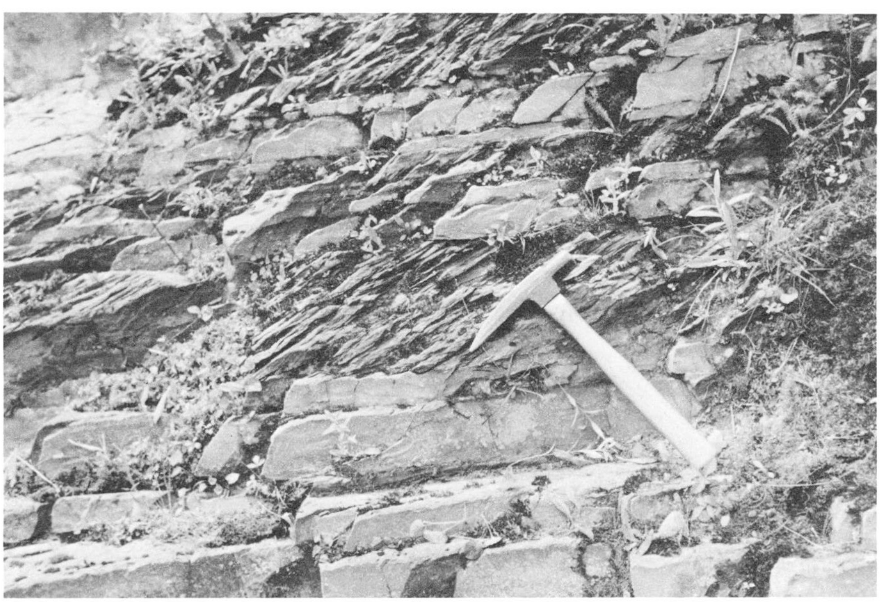

Figure 11

Slaty cleavage in slates interbedded with greywacke in Sedimentary unit, Wapske Formation on Wapskehegan River at the mouth of Sadler Brook. GSC 188515 facies) as indicated by the presence of albite, epidote and actinolite in most of the basalts (1DCvb) while that in the Wapske Formation is very low grade (prehnite-pumpellyite facies) as indicated by the presence of these minerals in vesicules in basalts (1DWvb) (Winkler, 1976). The Mississippian(?) Arthurette Redbeds are unmetamorphosed.

ECONOMIC GEOLOGY

The Rhyolitic unit of the Costigan Mountain Formation (1DCva) appears to be the most mineralized rock unit in the area. Interest in these rocks goes back at least to 1954 and 1955 when Selco Exploration Company Limited carried out geochemical stream sediment and soil reconnaissance surveys for heavy metals in the Costigan Mountain area. Anomalous values of lead, zinc and copper were found in the two streams draining the eastern part of the mountain. In 1960 the Costigan Syndicate staked the west flank of the mountain above the anomalous areas, and in 1962 carried out further geochemical surveys and found weak anomalies in the vicinity of the fire tower. In 1969 and 1970 International Geochemical Associates Limited (later Silcan Mines Limited) carried out a detailed stream and soil geochemical survey in the Costigan Mountain area and outlined an encouraging lead, zinc and copper anomaly east of the fire tower, and a silver and base metal anomaly 5 km to the southwest on the north side of Gulquac River (Riddell, 1971; St. Peter, 1978).

Amoco Canada Petroleum Company Limited began a regional stream silt geochemical survey in the area in 1973 and as a result of this and geophysical work staked the Costigan anomalous area, and in 1974 to 1976 outlined a sulphide zone by diamond drilling. Pyrite, pyrrhotite, sphalerite, galena and minor chalcopyrite and fluorite occur mainly as disseminated grains and fracture fillings in rhyolite flows, agglomerate and tuffs. In places the sulphides have replaced flow bands. Preliminary estimates indicate the higher-grade material (3 to 6 per cent zinc and lead) is confined to a zone 18 to 30 m wide, but its strike length is not known (Davies, 1976).

Two minor gold occurrences have been reported in the Wapskehegan River watershed. One of uncertain location is on Wapskehegan River about 5 km above the mouth of Sadler Brook (probably in the Rhyolitic unit (1DCva) near the base of Deer Mountain) where several pits in pink rhyolite and green diabase were dug in 1940 (St. Peter, 1978). Nine samples were assayed; four contained gold (0.005 to 0.01 oz. per ton) and seven contained silver (0.02 to 0.06 oz. per ton). The second showing is on the Plaster Rock-Renous Highway (108) 22.7 to 25.3 km east of Plaster Rock (of uncertain location, but probably north of Sadler Mountain) where shallow pits were put down in 1940 (St. Peter, 1978).

During the course of the mapping, several sulphide occurrences, mainly in the Rhyolitic unit of the Costigan Mountain Formation (1DCva), were noted. Disseminated pyrite makes up 5 to 10 per cent of rusty fractured rhyolite intercalated with shale and greywacke on Lake Branch Gulquac River 0.6 km above its mouth, and pyrrhotite in disseminations and veinlets makes up to 10 per cent of a greenish grey, fine grained, vaguely laminated, limy, rhyolitic tuff 1.1 km west of Beaver Lake in the southeastern part of the map area. Pyrrhotite is also present in a chert-bearing vesicular basalt overlying a basalt-slate mélange (peperite) on Wapskehegan River 1.6 km southeast of Ryans Brook. Pyrite was observed by Irrinki (1977c) in the rocks along Lake Branch Gulquac River and Gulquac River up to 1.5 km above their junction, and in basalt up to 1.2 km along the south-flowing tributary west of the junction, and chalcopyrite was seen on Lake Branch Gulquac River 1 km from the junction.

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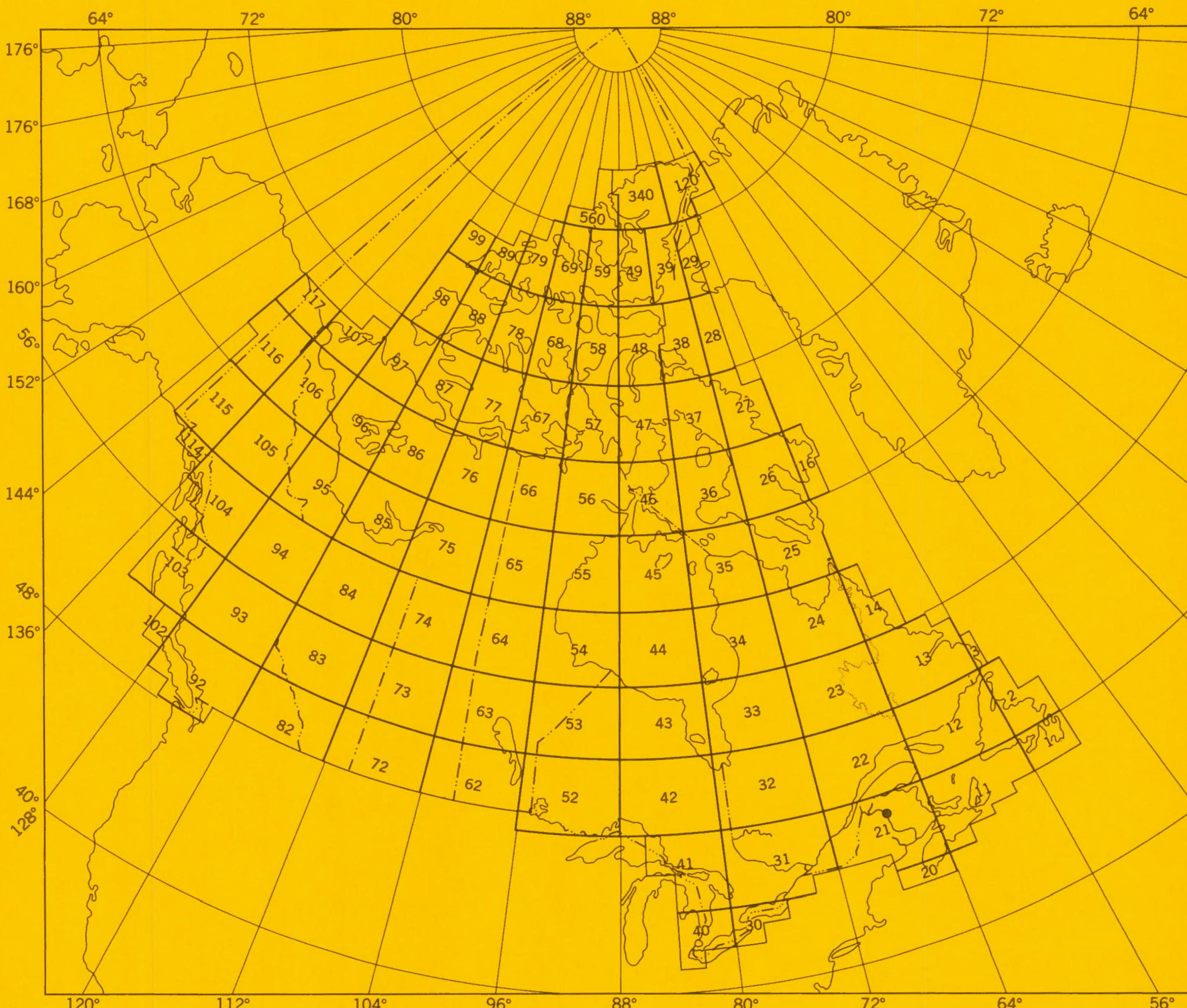

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