common rocks in manitoba

FOREWORD

This booklet is intended as an introduction to the study of rocks for the layman in Manitoba. Although not designed as a detailed field guide, localities in which various rocks occur have been selected on the basis of accessibility from areas of high population density. These outcrop localities, mainly in the southeast, are not necessarily the best to be found in the Province for any particular rock type, but they are located, as far as possible, where they can be reached by a large proportion of Manitobans and visitors.

A brief preliminary account of the geology of Manitoba has been included, suggesting extended areas of interest for those able to reach the less accessible regions of the Province.

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COMMON ROCKS IN MANITOBA

Geology is the study of the planet Earth as a physical body. The Earth is made of rock which forms a solid crust at the surface but is molten in the interior. The thickness of the rock-crust varies from place to place but is believed to be generally less than 30 miles. This is only a very small proportion of the Earth's total diameter of about 7,900 miles. Hence most of the Earth's interior consists of hot molten rock, and only a relatively thin crust has cooled sufficiently to form the solid rocks observed at the surface. From chemical analyses of thousands of rock samples, it has been calculated that eight elements make up nearly 99% of the Earth's crust. Oxygen represents nearly half of the crust and silicon over a quarter; other elements present are aluminum (8%), iron (5%) and calcium (less than 4%); relatively minor are sodium, potassium and magnesium (each between 2% and 3%). Various combinations of these elements (and other less plentiful elements) make up a variety of minerals, such as quartz, feldspar and many others. A mineral can be defined as a naturally occurring, homogeneous substance having a definite chemical composition, distinctive physical properties and, if formed under favourable conditions, a recognizable crystalline form. Although some 2,000 minerals are known, there are only a dozen or so common, rock-forming minerals. A rock is simply a mixture of various minerals. Whereas individual minerals rarely exceed a few inches in length, and are usually much smaller, rocks can form huge masses extending for many miles. The average mineral composition of a few common rocks are shown in the accompanying table (Table 1).

TABLE I : AVERAGE MINERAL COMPOSITIONS OF SOME COMMON ROCKS (Holmes)

Minerals	Igneous Rocks		Sedimentary Rocks		
	Granite	Basalt	Sand-stone	Shale	Limestone
Quartz	31.3	--	69.8	31.9	3.7
Feldspars	52.3	46.2	8.4	17.6	2.2
Micas	11.5	--	1.2	18.4	--
Clay minerals	--	--	6.9	10.0	1.0
Chlorite	--	--	1.1	6.4	--
Amphibole	2.4	rare	--	--	--
Pyroxene	rare	36.9	--	--	--
Olivine	--	7.6	--	--	--
Calcite & dolomite	--	--	10.6	7.9	92.8
Iron oxides & sulphides	2.0	6.5	1.7	5.4	0.1
Other minerals	0.5	2.8	0.3	2.4	0.3

When an engineer is planning to build a large bridge or skyscraper, he prefers that the foundation should rest upon bedrock rather than overburden. Overburden is a general term for the soil, clay, sand and gravel that has accumulated on top of the solid bedrock. Overburden varies greatly in thickness from place to place, from a few inches to a few hundred or more feet. Overburden includes loose stones and boulders that are not attached to the underlying bedrock. Outcrops are visible showings of bedrock that project through the overburden. In many parts of Manitoba, the best outcrops are found around lakeshores where overburden has been washed away by the water. Geologists are constantly searching for outcrops, which they record on geological maps to show the distribution of various kinds of bedrock. Where necessary however, special geological maps are prepared to show the nature of the overburden; such maps are very useful in locating sand and gravel deposits needed for construction of highways, dams and other large structures.

A. Rock classification

The first consideration in rock classification is mode of origin. The four main classes of rock, with simple examples of each, are:

I IGNEOUS ROCKS (formed through heat): when molten lava comes out of a volcano, for example, it cools and solidifies to form igneous rocks such as basalt; other igneous rocks (Table 2) such as granite are formed at greater depth by crystallization of molten rock-material (magma).

II SEDIMENTARY ROCKS (formed from sediments): rivers carry suspended sand and mud downstream to the sea where they deposit their loads, thus building up sandbanks and mudbanks; these gradually become buried beneath later deposits, and in the course of time the sediments become compacted to form sandstone, mudstone, etc.

III VOLCANICLASTIC ROCKS (formed from broken volcanic fragments): fragmentation may be caused for example by explosive eruptions; the resulting debris gradually becomes buried and consolidated as various types of volcaniclastic rock.

IV METAMORPHIC ROCKS (formed by alteration): rocks that are affected by heat and pressure undergo various changes due to destruction of some of their minerals and replacement by new minerals, a process called metamorphism (meaning change of form). This process of recrystallization is illustrated by marble, a metamorphic rock composed of crystals of calcite (calcium carbonate) which have been formed from alteration of limestone (a sedimentary rock composed of non-crystalline calcium carbonate).

TABLE 2 : IGNEOUS ROCKS:- A simplified classification

VOLCANIC ROCKS	PLUTONIC ROCKS	OTHER MAIN MINERALS	FELDSPAR	GENERAL ROCK COLOUR
RHYOLITE	GRANITE	QUARTZ Biotite Hornblende	Mainly potassic	PALE (acidic rocks)
TRACHYTE	SYENITE	Pyroxene Hornblende Biotite		
QUARTZ LATITE	GRANODIORITE AND QUARTZ MONZONITE	QUARTZ Biotite Hornblende	Sodic and potassic	
LATITE	MONZONITE	Pyroxene		
DACITE	TONALITE (QUARTZ DIORITE)	QUARTZ Biotite Hornblende Pyroxene	Soda-lime	INTERMEDIATE
ANDESITE	DIORITE	Hornblende Biotite Pyroxene		
BASALT	GABBRO	Pyroxene Hornblende Olivine	Lime-rich	DARK (basic rocks)
Very rare	PERIDOTITE PYROXENITE HORNBLENDITE	Olivine Pyroxene Pyroxene Hornblende	None	

Table 3: SOME OUTCROP LOCALITIES IN SOUTHEASTERN MANITOBA*

1 Shoal Lake: GREENSTONE, rhyolite

2 Snake Lake: GREENSTONE, rhyolite

3 West Hawk - Falcon Lakes area: See Fig. 3

4 Greer Lake: GNEISS, pegmatite

5 Ryerson Lake: PEGMATITE, greenstone

6 Booster Lake: PEGMATITE, conglomerate, greywacke

7 Bernic Lake: GREENSTONE, pegmatite

8 Shatford Lake: GNEISS

9 Lac du Bonnet: QUARTZ MONZONITE, granite, gneiss, quartzite

10 Bird River: GABBRO-PERIDOTITE SILL

11 Bird Lake: TONALITE, gabbro-peridotite, greywacke, arkose

12 Starr Lake: CONGLOMERATE

13 Cat Lake: TONALITE

14 Flintstone Lake: GREYWACKE-ARGILLITE, paragneiss, mica schist

15 Finger Lake: ARGILLITE (mud-stone), MYLONITE, green schist

16 Gem Lake: VOLCANIC rocks, mainly pyroclastic

17 Garner Lake: PYROXENITE-PERIDOTITE, CONTACT ROCKS, greywacke-argillite, mica schist, paragneiss, granite, basalt

18 Wallace Lake: Altered volcanic and sedimentary rocks with some IRON FORMATION

19 Long Lake: VOLCANIC BRECCIA, TUFF BRECCIA, GREYWACKE

20 Manigotagan Lake: PARAGNEISS, QUARTZ MONZONITE

21 Quesnel Lake: PARAGNEISS with white pegmatite

22 Rice Lake: RHYOLITE, FELDSPATHIC QUARTZITE

23 Wanipigow Lake: QUARTZ DIORITE, QUARTZ-FELDSPAR PORPHYRY, volcanic breccia, tuff, argillite with IRON FORMATION

24 Wanipigow River (west): BASALT

25 Manigotagan: Paragneiss

26 Black Island: SANDSTONE

27 Deer Island: SANDSTONE, SHALE

28 Grindstone Point: SANDSTONE, LIMESTONE

29 Punk & Little Punk Islands: Sandstone, SHALE

30 Hecla Island: LIMESTONE

31 North of Riverton: Dolomite

32 Winnipeg River: GREENSTONE, QUARTZ MONZONITE, GNEISS, pegmatite

33 Julius: Peat moss

34 Garson: LIMESTONE

35 Stony Mountain: DOLOMITE

36 Spearhill: LIMESTONE

37 Gypsumville: GYPSUM, ANHYDRITE

* Numbers correspond to localities shown in Figure 1 (Locality Map).
A few localities mentioned in the text fall outside Figure 1 but can be found on the Highway Map of Manitoba, available cost-free at Provincial agencies.

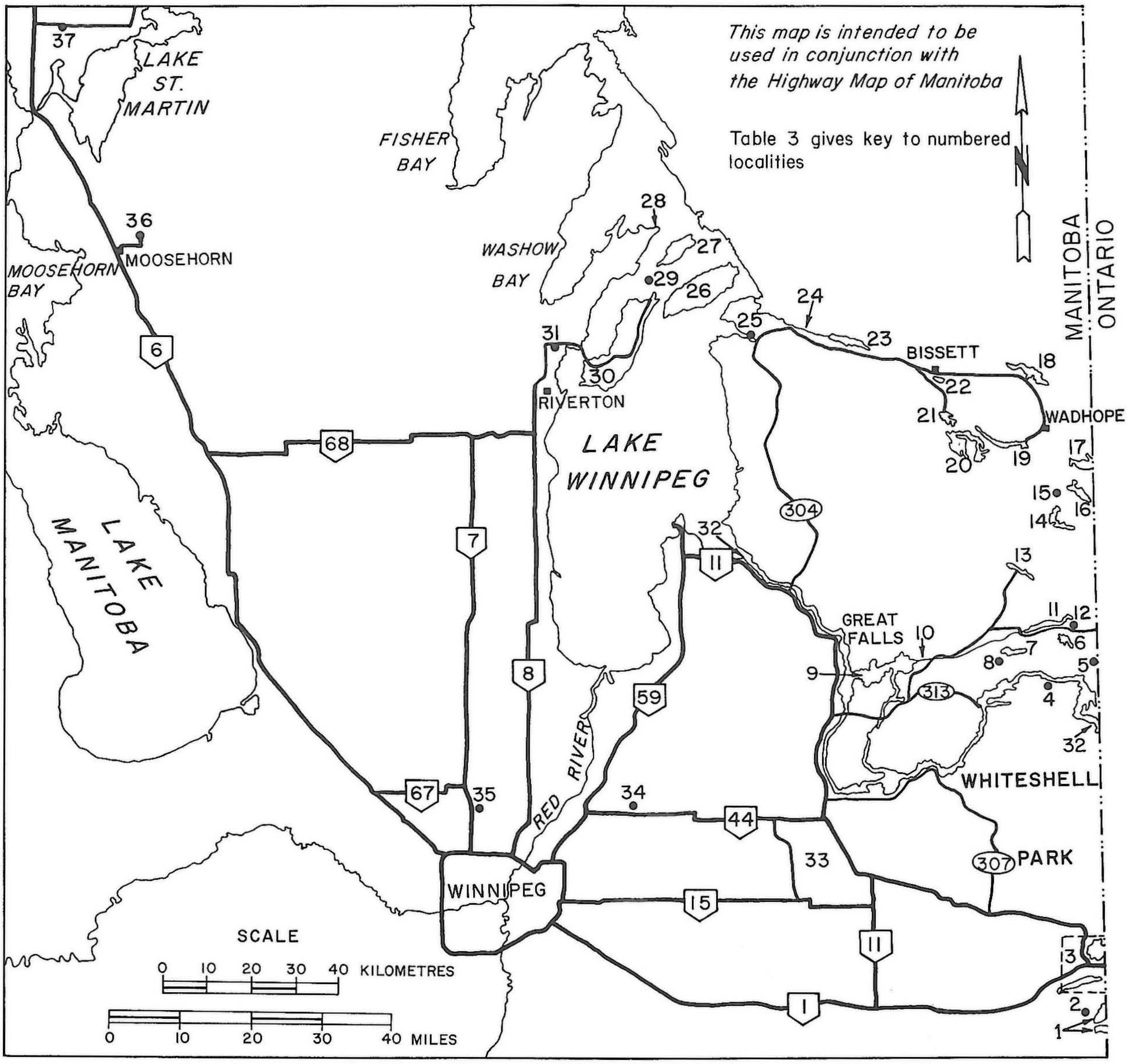


Figure 1: Locality Map

B. Igneous rocks

Igneous rocks are formed from hot molten material called magma. Magma that reaches the Earth's surface to flow out of a volcanic opening is called lava. As lava cools and solidifies it forms rocks such as basalt (plate 1) and rhyolite (plates 2, 3). *Accessible outcrops of basalt can be found between Falcon Lake and West Hawk Lake (3)*. Good examples of pillow-basalt (c.f. plate 14) occur along the Wanipigow River (24). Rhyolite is much less plentiful but small bodies can be seen with other volcanic rocks in the Shoal Lake area (1) between Indian Bay and Snowshoe Bay, and immediately southwest of Snake Lake (2). Further north, the south shore of Rice Lake (22) shows some massive rhyolite.* The minerals that make up a volcanic igneous rock are mostly so small that they can be clearly seen only under a micro-

PLATE NO. 1: BASALT: pits due weathering out of some olivine crystals

* Such numbers refer to localities as shown in figure 1 and table 3.

PLATE NO. 2: RHYOLITE outcrop showing primary flow banding (Gem Lake)

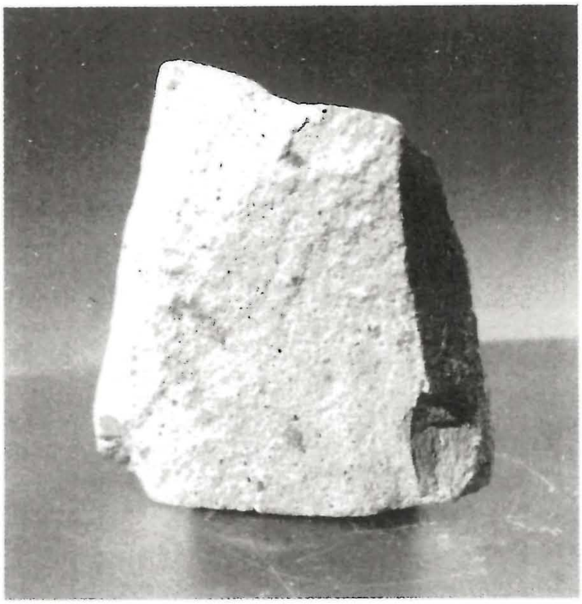


PLATE NO. 3: RHYOLITE specimen

scope. This is clearly because lavas cool rapidly when they reach the surface, leaving insufficient time for the growth of crystals. Some lava-rocks, however, contain scattered large crystals (phenocrysts) that stand out against a fine-grained groundmass. In some cases the phenocrysts were formed before the lava reached the surface. The resulting rock is called a porphyry. If the mineral that forms the phenocrysts is feldspar (as is common), the rock might be called feldspar porphyry. *A small body of quartz-feldspar porphyry occurs by the north shore of Falcon Lake (east end), southeast of Camp Lake (3). Similar rock crops out on the south shore of Wanipigow Lake (23).*

Magma that does not reach the surface, but gradually cools and solidifies at depth, gives rise to another important group of rocks - the igneous intrusions, so-called because they have forced their way while still molten into all kinds of openings within or between pre-existing rocks. Those affected in this way by intrusion are called the country rocks; it is not uncommon for them to become engulfed or assimilated by a large molten intrusion. Such widespread effects are typical of the plutonic (deep-seated) intrusions which commonly occur in huge masses (plutons) many miles in extent. *Large plutons are common in Manitoba. One example occupies the entire south shore of Lac du Bonnet (9) and extends some miles to the east, west and south. Granite (plates 4, 5, colour section) is perhaps the best known example of a plutonic rock. The Lac du Bonnet pluton consists of granite and closely related rocks. A grey granite can be seen in the northern bay of West Hawk Lake, and some pink, porphyritic granite occurs immediately east of Falcon Lake (3).* Like all plutonic types, granite is relatively coarse-grained because its minerals had time to grow to a fair size before the magma cooled. Its constituent minerals (mainly feldspar, quartz and mica, in that order) can be readily seen. This immediately distinguishes granite from its volcanic equivalent (rhyolite) which is often so fine-grained as to appear almost glassy at first sight. Both these rocks are nevertheless similar in composition.

Hence plutonic rocks are said to be coarse-grained, in contrast to the fine-grained volcanic rocks. Intermediate types also occur: small bodies of magma that solidify at relatively shallow depths give rise to medium-grained or porphyritic igneous intrusions called dyke-rocks; in geology, the word dyke describes an igneous body that is shaped something like a long wall. These are relatively small bodies that were injected when molten so as to cut across the country rocks. *Similar bodies injected along (instead of across) the layering are called sills; the Bird River sill (10) is a good example in southeast Manitoba (plate 6). Stocks*

PLATE NO. 6: GABBRO-PERIDOTITE outcrop (Bird River sill) *are non-elongated intrusions, rarely more than a few miles in diameter; the Falcon Lake stock (3) is a good example.*

Igneous rocks are next classified by their compositions, as indicated by the minerals they contain (Table 2). Amongst the plutonic types, two of the most distinctive groups are the granites and the gabbros. Granites contain mainly pale coloured minerals and usually appear pinkish, pale grey or almost white, depending upon the colour of the feldspar, which is the principal constituent. Gabbros (plates 7, 8), on the other hand, contain little or no quartz, and normally are dark-coloured (mafic) owing to the presence of ferromagnesian (iron-magnesium-rich)

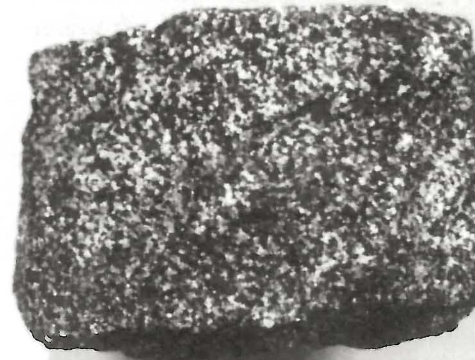
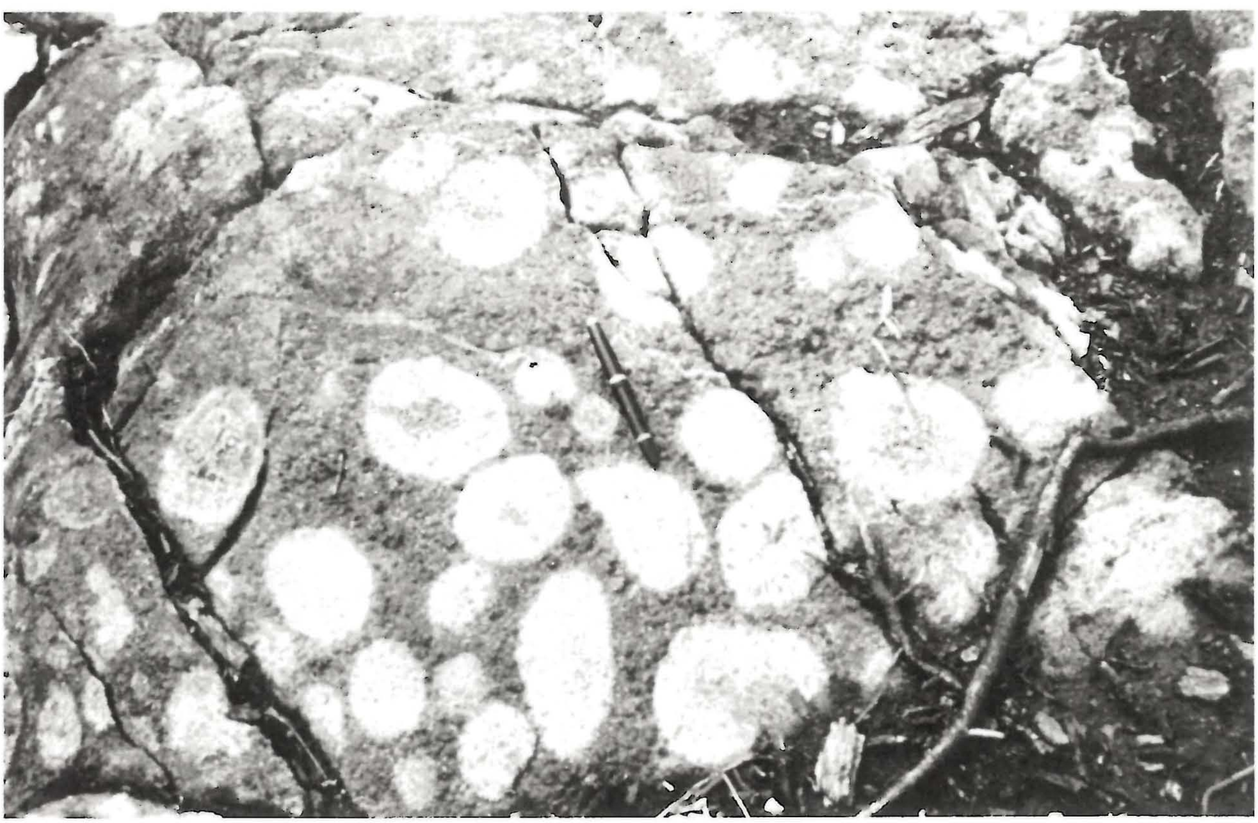


PLATE NO. 8: GABBRO specimen

PLATE NO. 7: GABBRO outcrop showing rounded clusters of feldspar (Snow Lake)



minerals such as pyroxene, amphibole or olivine. *The outer zone of the Falcon Lake stock (3) contains much coarse black hornblende-gabbro. Ultramafic rocks are even richer in ferromagnesian minerals; thus peridotite contains much olivine, and pyroxenite (plate 9) consists mainly of pyroxene; both rocks occur with gabbro in the Bird River sill (10), well exposed on the northwest shore of Bird Lake (11). Pyroxenite and peridotite also crop out on islands in Garner Lake (17).* Hence richness in iron, magnesium and calcium distinguishes the gabbros and ultramafic rocks from the granites, which are characterized by much free silica (SiO_2) in the form of quartz. These colour differences also apply generally to the volcanic igneous rocks (Table 2), even where the individual minerals can hardly be seen. Basalt (the volcanic equivalent of gabbro) is usually dark green or black, whereas rhyolite (equivalent of granite) is normally pale in colour. More decisive than colour, however, is the comparative weight (specific gravity). A hand-specimen of basalt feels considerably heavier than one of rhyolite, because it contains more heavy (ferromagnesian) minerals. Hence basic rocks (Table 2) are both darker and heavier than acidic rocks (Table 2) because they are richer in heavy ferromagnesian minerals.

Quartz monzonite and granodiorite are two common plutonic rocks that strongly resemble granite and are usually distinguished from it after microscopic examination of the feldspars. *Quartz monzonite is the dominant rock in the Lac du Bonnet (9) pluton, and in a smaller pluton that crops out around the southeast shores of Manigotagan Lake (20). Quartz monzonite also forms the core of the Falcon Lake stock (3). Porphyritic granodiorite forms the south shore and nearby islands of Falcon Lake where numerous outcrops can be seen (3).*

Intermediate between the granitic and gabbroic rocks are the diorites (plate 10, colour section). Chemically they contain more silica than gabbro but less than granite; the more siliceous types are called quartz diorite or tonalite. *Black and white hornblende-diorite is predominant in the outer zone of the Falcon Lake stock (3); it is 75% white feldspar. Tonalite is more abundant than diorite in Manitoba. A tonalitic pluton extends from Bird Lake (11) north to Cat Lake (13) and west almost to Great Falls (fig. 1). Rocks of the same composition (quartz diorite) are extensive north of Wanipigow Lake (23), and crop out on the northwest shore.*

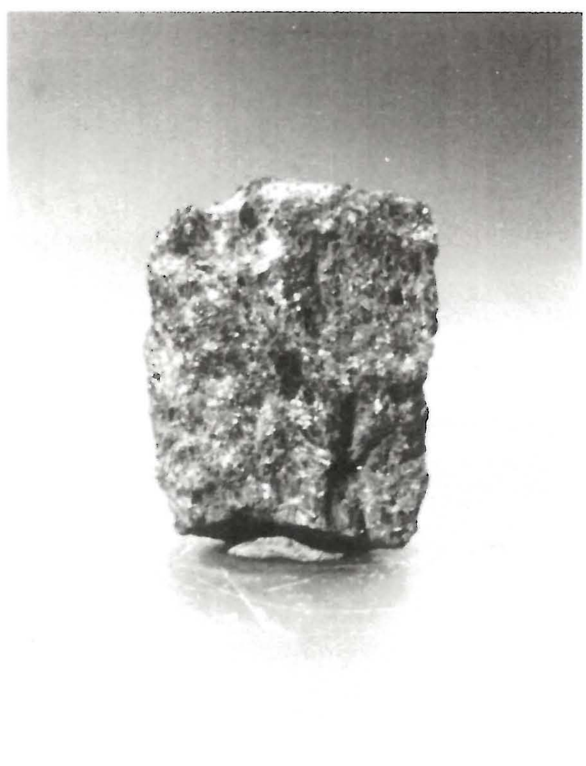


PLATE NO. 9: PYROXENITE specimen

Also frequently encountered in Manitoba is pegmatite (plates 11, 12), occurring as a very coarse-grained type of granite, typically in the form of small dykes, sills or veins. *Coarse pink pegmatite intrudes the volcanic rocks near West Hawk Lake. Outcrops can be found within an east-west zone about 1/4 mile wide that is crossed by Highway 44 about 1 1/2 miles north of Star Lake (3). Larger bodies of pegmatite crop out on the south bank of the Winnipeg River (32) in the Whiteshell Park, and 5 miles to the north at Booster Lake (6).*

The volcanic equivalent of diorite is called andesite (plates 13, 14). This is a dark coloured lava-rock, relatively abundant in Manitoba, that may at first sight resemble basalt. *The volcanic rocks between West Hawk and Falcon Lakes*

PLATE NO. 11: PEGMATITE dyke: quartz bordered by feldspar (Manigotagan River)

PLATE NO. 12: Gneiss intruded by PEGMATITE (Quesnel Lake)

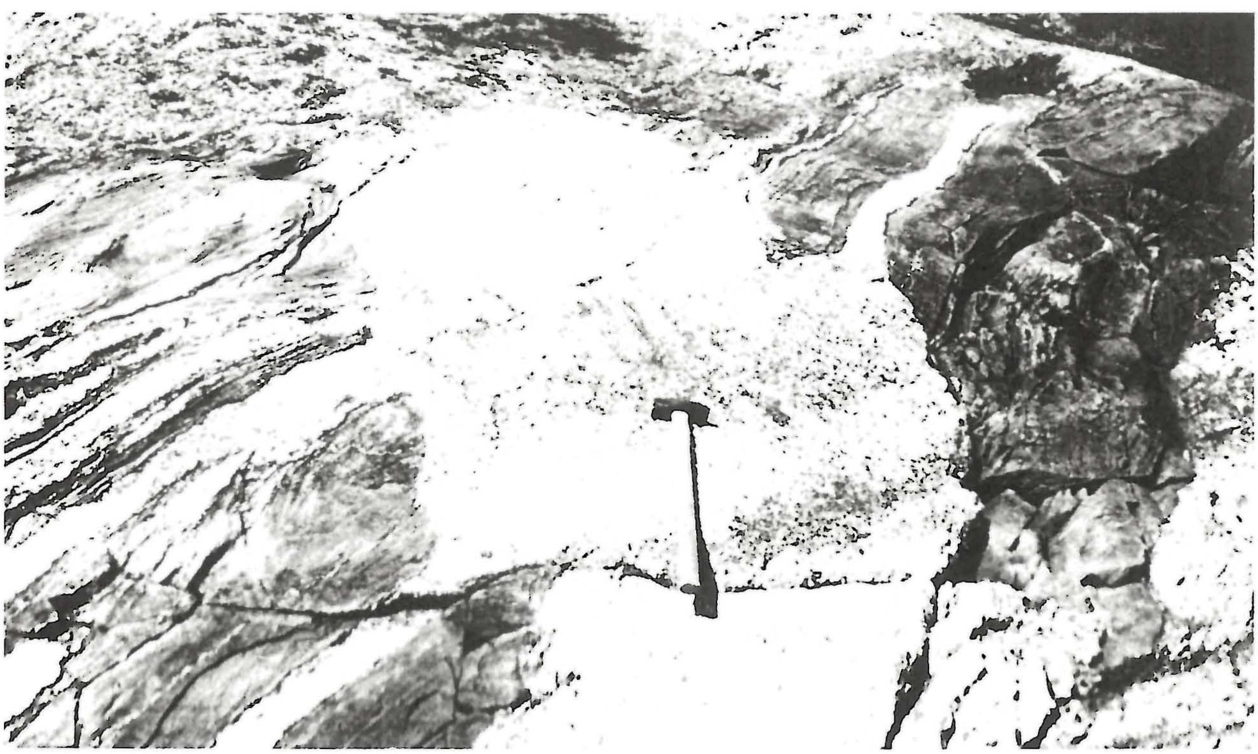


PLATE NO. 13: ANDESITE outcrop (Gods Lake)

(3) are predominantly andesite, distinguished from the associated basalt by laboratory tests. These, and other volcanic rocks, occur in the so-called greenstone belts. Green minerals such as chlorite give many of these rocks (especially basalt and andesite) a dark greenish appearance. *Some greenstone belts extend for many miles in Manitoba, but they are relatively narrow. East-west belts in the southeast crop out west of Shoal Lake (1, 2), north of Falcon Lake (3), along the south bank (32) of the Winnipeg River (Whiteshell Park), and between Ryerson (5) and Bernic (7) Lakes. The last two are profusely intruded by large pegmatite bodies.*

PLATE NO. 14: ANDESITE showing pillows, formed when lava erupted under sea (Gods Lake)

C. Sedimentary rocks

Grain-size is a principal factor in the classification of sedimentary rocks, especially those that were formed, like sandstone (plate 15, colour section) from material transported in suspension by water. Most sandstones were formed where there was once a sea-shore, and they consist mainly, but not exclusively, of quartz grains, because quartz resists solution and disintregation better than most minerals. One exception, however, is arkose (plate 16) which is a feldspathic sandstone containing major feldspar as well as quartz grains. *Excellent examples of quartz-sandstone (plate 17, colour section) can be seen on Black Island (26) in Hecla Provincial Park (plate 18). Arkose is exposed very close to the south bank of the Bird River, at its outlet from Bird Lake (11),* The breakdown of pre-

PLATE NO. 16: ARKOSE specimen

PLATE NO. 18: SANDSTONE shoreline (Black Island)

existing rocks where they are exposed to the atmosphere begins with a process called weathering. If you break off a piece of rock from an outcrop, you can sometimes see that the outer "skin" looks different in colour and texture from the fresh, unweathered rock beneath the surface. This is due to the action of air (oxidation) and water (partial solution). The soft weathered skin is constantly undergoing erosion by the action of rain, ice and wind, leading to the gradual movement of rock detritus down rivers, ultimately to the sea. More spectacular episodes of erosion are occasionally seen in the form of landslides. Erosion is obviously much more rapid in mountainous terrain than in flat-lying country.

All sedimentary rocks, in the process of consolidation from loose sediments, undergo varying degrees of cementation due to percolation by water containing more or less soluble compounds of elements such as calcium, iron and silicon. Loose sands may thus become calcareous, ferruginous or siliceous sandstones. A striking feature of most sedimentary rocks, best seen in cliffs or other vertical sections, is their bedding (plate 19, colour section), a form of layering acquired during primary deposition. *This can be seen in the Hecla Park and is shown by many other outcrops in Manitoba.*

Sandstone laid down under the sea is called marine sandstone *(as seen in the Hecla area)*. Smaller bodies of sandstone (and other sedimentary rocks) are laid down in lakes and rivers. However, it is on the seashore that the formation of detrital sedimentary rocks can be best illustrated. Beneath the cliffs, or near the limit of the waves that roll at high tide, a pebbly beach is often found. The pebbles are smooth and water-worn after being constantly

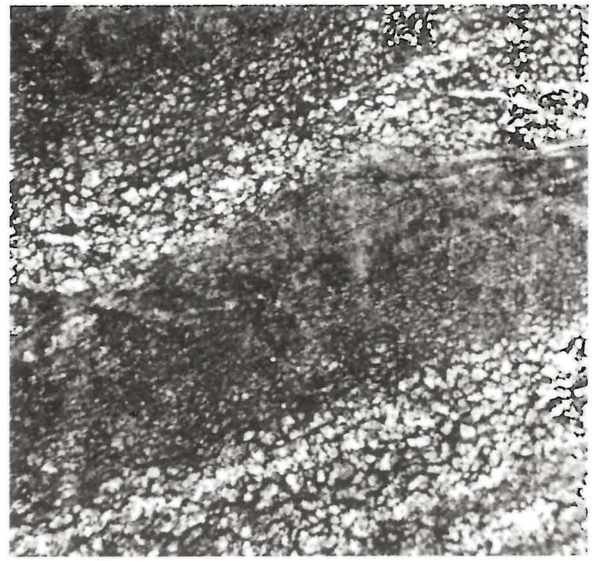


PLATE NO. 20: CONGLOMERATE grading to GREYWACKE (Southern Indian Lake)

rubbed against each other by wave-action. The softer and smaller rock and mineral particles are washed out of the pebble beach and carried out to sea by the undertow. When eventually the pebble beach becomes buried, cemented and consolidated, it forms a rock called conglomerate (plates 20, 21). *Conglomerate outcrops, accessible from Provincial*

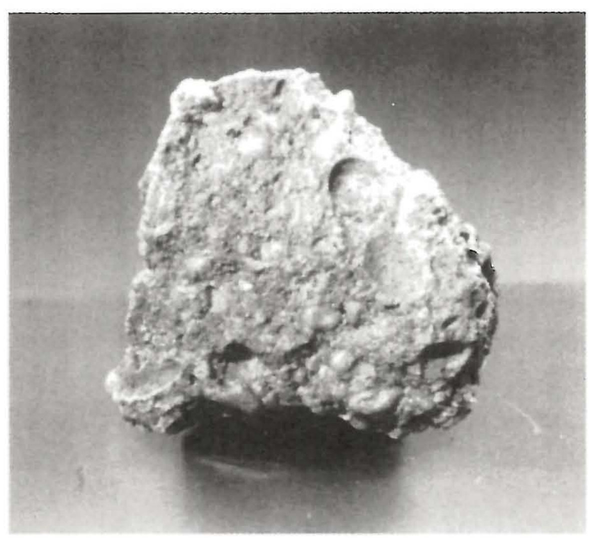


PLATE NO. 21: CONGLOMERATE with quartz pebbles

Road 315, can be seen on the south shore of Starr Lake (12) and on the northeast shore of Booster Lake (6).

A little way offshore, where the water is quite shallow, but too deep for the waves to roll pebbles along the sea-floor, sand deposition takes place, eventually to form sandstone. Sandstones are much more extensive than conglomerates which are confined mainly to the shoreline (and to nearshore zones where very strong currents prevail). Between the sandstones and the conglomerates, pebbly and gritty sandstones are often found. Grit is a coarse sand, consisting of angular (not rounded) fragments; some particles may be the size of small pebbles. *Pebbly sandstone can be found near the base of some of the Black Island (26) and Deer Island (27) sandstone cliffs.* Greywacke (plates 20, 22) is a sedimentary rock containing sandy, gritty and larger particles (including angular rock fragments several inches long) set in a grey fine-grained argillaceous (mud-like) groundmass. *These original characteristics are rarely preserved in Manitoba greywackes, owing to metamorphic effects (described subsequently). Altered greywacke can be seen however at the east end (south shore) of Bird Lake (11), and the west shore of Booster Lake (6). Further north it is exposed along the south shore of Long Lake (19) and the southwest shore of Flintstone Lake (14).*

In deeper, relatively quiet waters where the mudbanks form, the muddy sediments eventually become consolidated as mudstone (a massive, non-laminated rock), or shale (a laminated rock, plates 23, 24), or clay (an exceedingly fine-grained rock that has the property of plasticity when wet). These rocks (which are collectively called argillites) are formed of colloidal rock-residue, together with

PLATE NO. 22: GREYWACKE-CONGLOMERATE

PLATE NO. 24: SHALE specimen

PLATE NO.15: SANDSTONE specimen

PLATE NO.17: Cliff formed of quartz-SANDSTONE (Black Island)

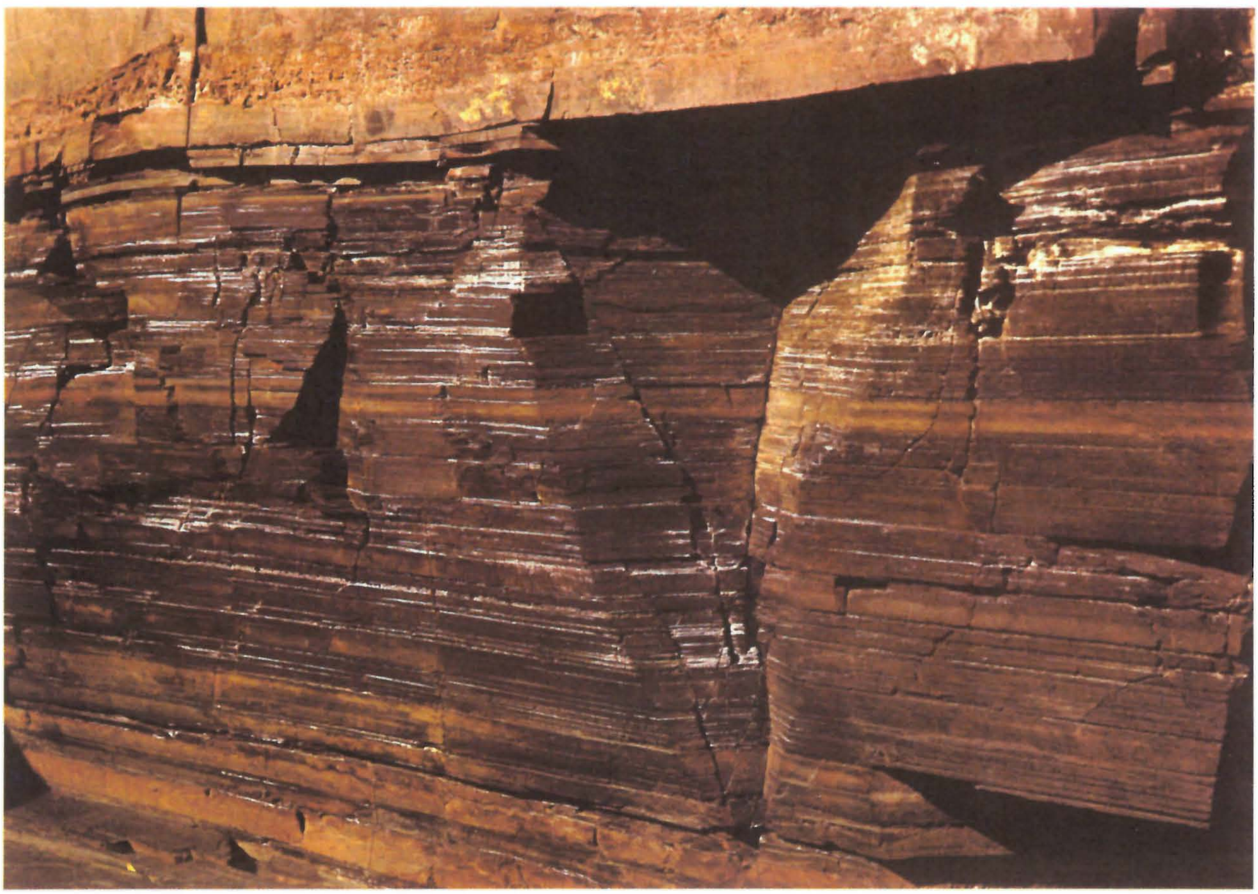


PLATE NO.19: IRON FORMATION: pale chert beds and dark iron-rich beds

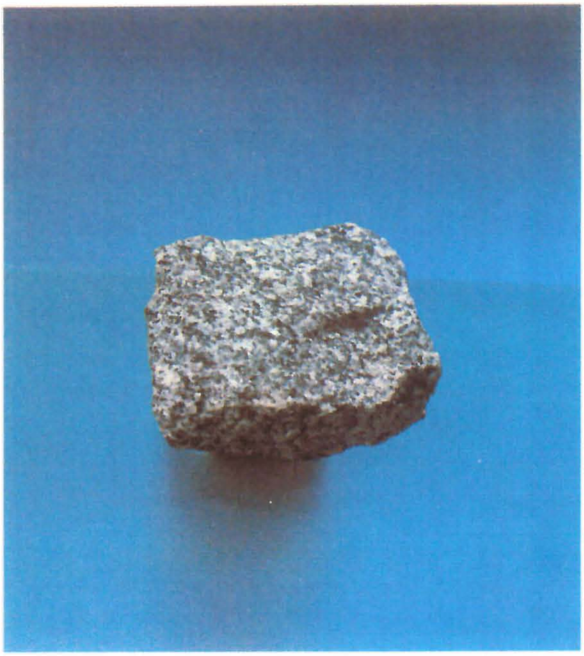


PLATE NO. 4: Biotite GRANITE

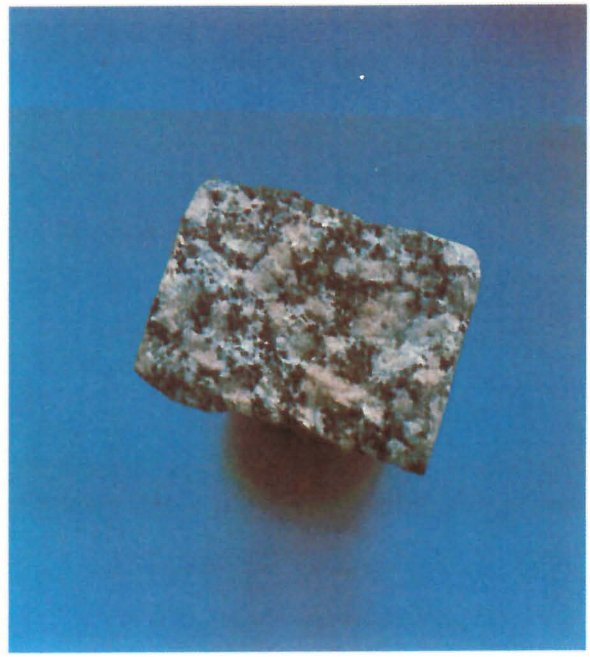


PLATE NO. 5: Porphyritic GRANITE (feldspar phenocrysts)

PLATE NO. 10: DIORITE outcrop (East Braintree)

PLATE NO.23: SHALE exposed in road cutting (Treherne)

PLATE NO.25: A crystal of GYPSUM

PLATE NO.27: DOLOMITE crystals

PLATE NO.33: Biotite SCHIST

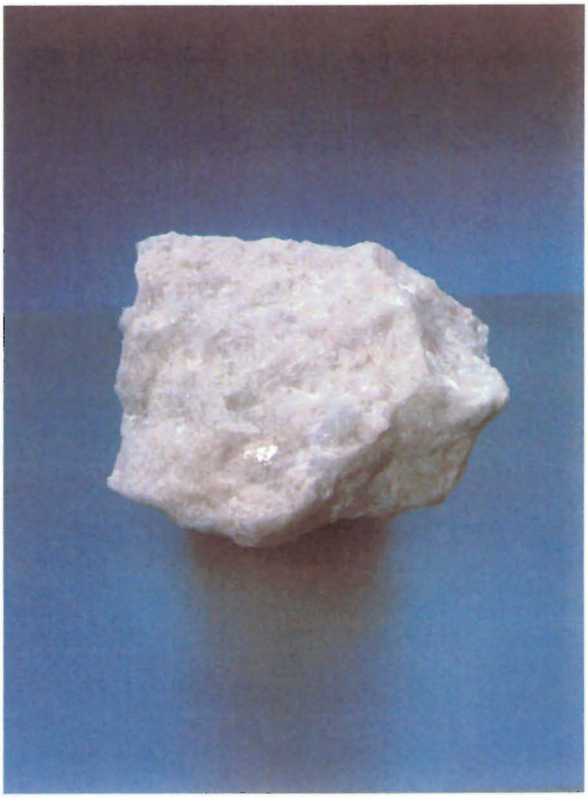


PLATE NO. 34: MARBLE specimen

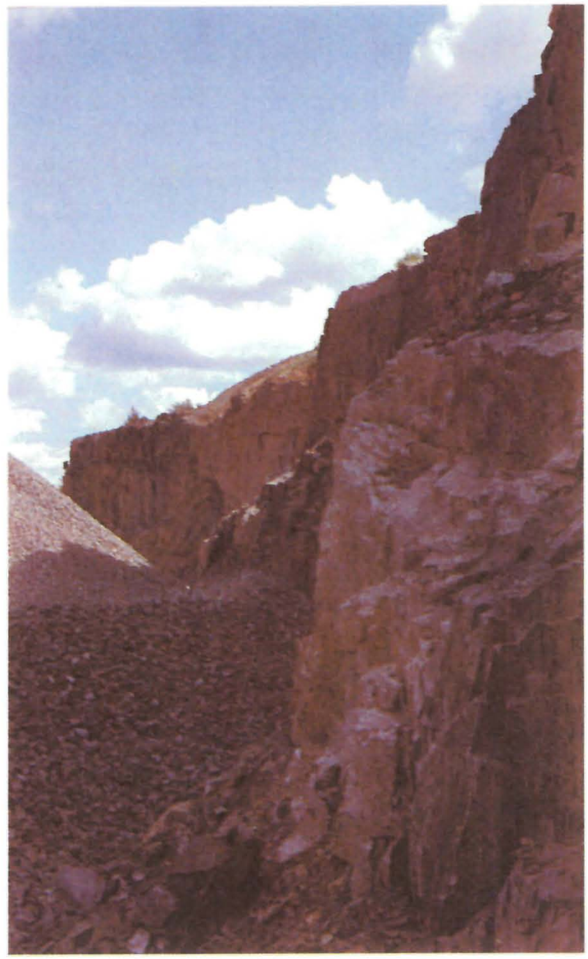


PLATE NO. 35: QUARTZITE quarry (Manasan)

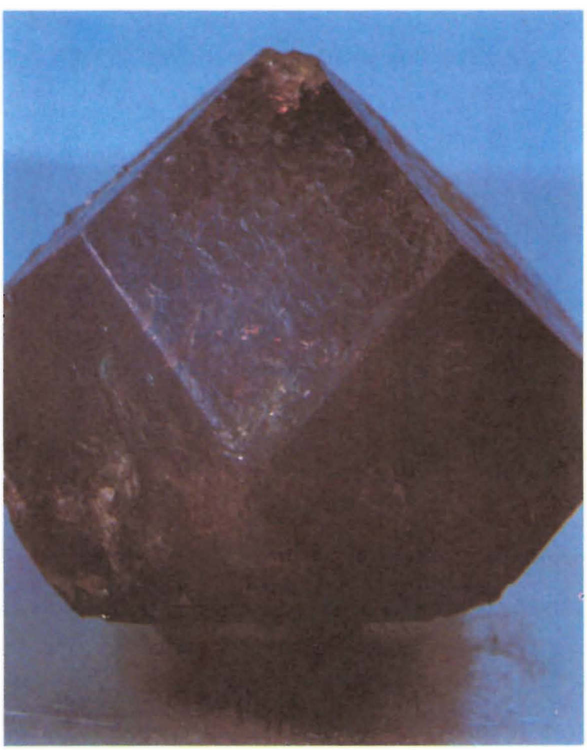


PLATE NO. 36: GARNET crystal

a considerable proportion of rock-flour derived from the grinding down of larger particles. *Green shale overlies the sandstone on Deer Island (27), Punk Island and Little Punk Island (29) in Hecla Park where it is exposed in beds up to 40 feet thick. Altered but recognizable argillite is abundant along the east shores of Flintstone Lake (14) and at Finger Lake (15).*

Other important, though much less abundant, sedimentary rocks are those formed from material carried in solution, in contrast to the detrital (or clastic) rocks just described. Such deposits are being formed today in the Dead Sea and other small inland seas and lakes in arid regions where evaporation is rapid. Under such conditions a class of rocks called evaporites may be formed, provided there is insufficient detrital sedimentation to outweigh the chemical precipitation. Sea-water holds the metallic ions sodium, magnesium, calcium and potassium in that order of abundance, and the acid radicles Cl, SO_4, CO_3 and Br. On evaporation, calcium carbonate is first deposited, followed by calcium sulphate and sodium chloride. Some limestones are thus formed by precipitation of calcium carbonate, but many others are formed largely from organic remains (as described in a subsequent paragraph). Calcium sulphate forms the commercially important deposits of gypsum ($CaSO_4 2H_2O$; plate 25, colour section) and anhydrite ($CaSO_4$); and sodium chloride forms rock-salt, which is preserved only in arid climates. *In Manitoba, beds of gypsum and anhydrite can be seen in quarries at and near Gypsumville (37). The Prairie Evaporite Formation of Manitoba occurs at depth but not at the surface; it gives rise to the brine springs that issue from the escarpment west of Lakes Manitoba and Winnipegosis.*

Both silica (SiO_2) and iron compounds can also be deposited as residues from solution, forming chert-rock and ironstone respectively. Chert is formed from solution by crystallization of a gelatinous precipitate, while ironstone originates in various ways, one of which is precipitation of colloidal ferric hydroxide. Some of the world's greatest iron deposits (e.g. Lake Superior) originated through co-precipitation of iron compounds and silica. *Localized chert and thin bands of associated "ironstone" occur with altered greywacke in metamorphosed sedimentary rocks around the northeast shores of Lac du Bonnet (9). Better examples of this strikingly banded rock, known as iron formation (c.f. plate 19), occur with altered volcanic and sedimentary rocks on the main island, adjacent peninsula, and northerly shores of Wallace Lake (18), east of Bissett. Iron formation can also be found with argillite along the north shores of Wanipigow Lake (23).*

Many limestones (plate 26) are composed largely of the shells or

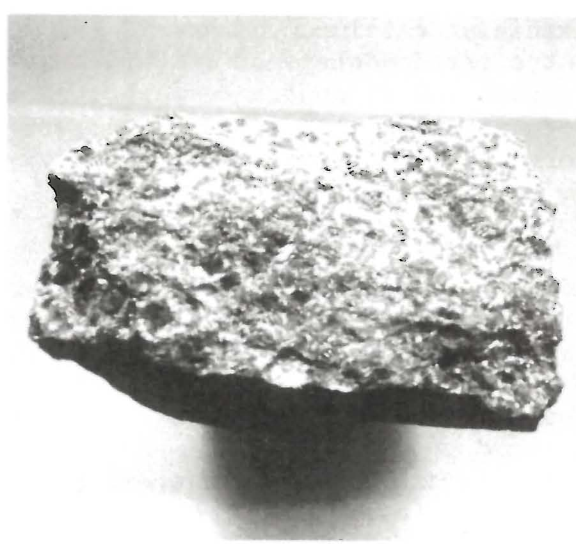


PLATE NO. 26: Fossiliferous LIMESTONE

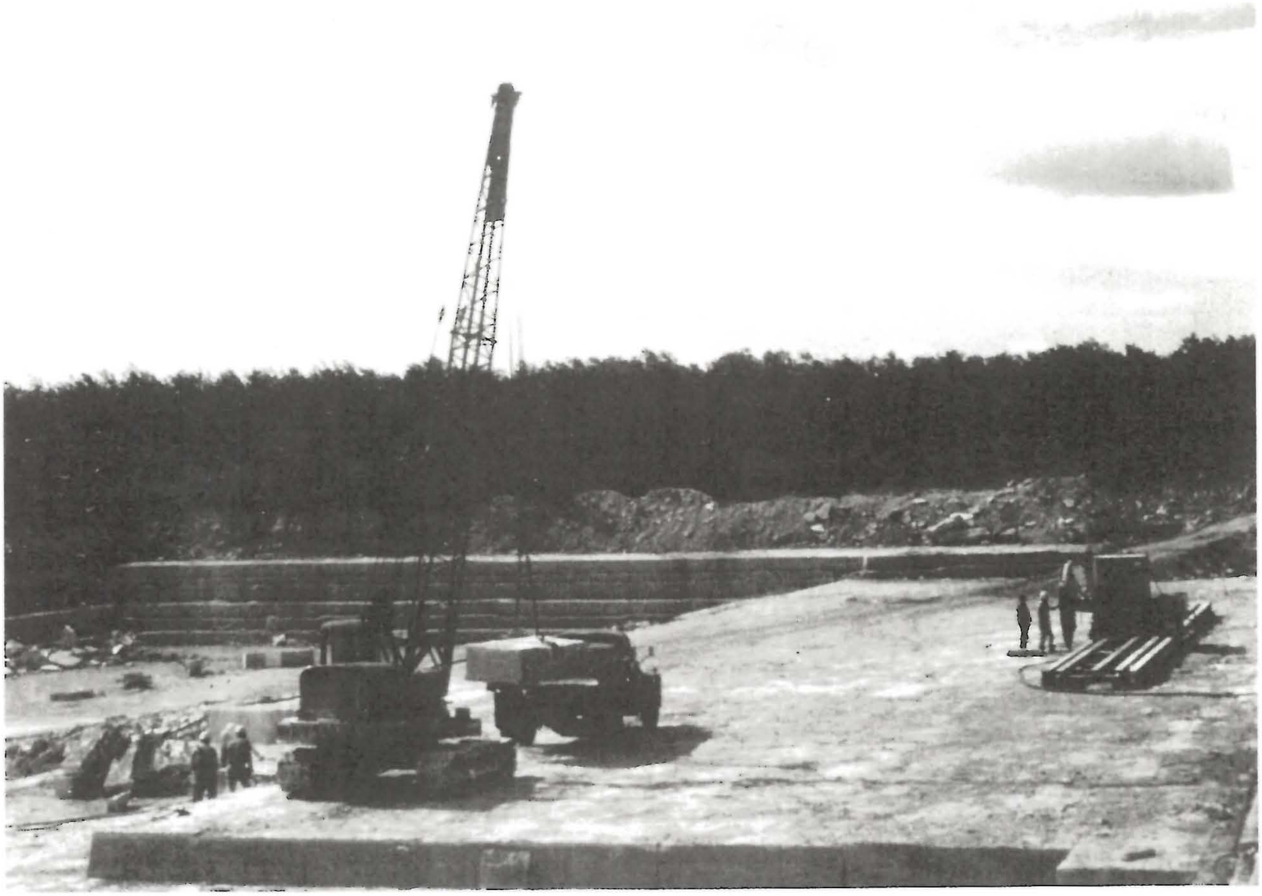


PLATE NO. 28: LIMESTONE quarried as Tyndall building stone (Garson)

other remains of marine animals and plants. The shells are composed mainly of calcium carbonate ($CaCO_3$), but after deposition the calcium may be replaced in part by magnesium to form magnesian limestone. A rock consisting mainly of the mineral dolomite, $CaMg(CO_3)_2$, is called dolomite (plate 27) or dolostone. *Relatively pure limestone occurs along the east side of Lake Manitoba; one of the best exposures is in the (now disused) Spearhill quarry (36), 4 miles northeast of Moosehorn. Mottled dolomitic limestone is extensive around the Red River and is quarried as building stone (plate 28) at Garson (34). Dolomitic limestone can be seen overlying the sandstone (plate 29) at Grindstone Point (28), and has been quarried at the extreme northern tip of Hecla Island (30). This rock forms much of the southwest shore of Lake Winnipeg. Dolomite is exposed at various quarries in the Stonewall-Stony Mountain (35) area. Cherty dolomite is exposed in a quarry (31) 4 miles west of the Hecla Island causeway (P.R. 233); the quarry provided stone for construction of the causeway. Dolomite is very abundant in an east-west zone that includes the Clearwater Provincial Park, Cormorant Provincial Forest and the southern part of the Grass River Provincial Park (east of Cranberry Portage).*

Other sedimentary rocks composed largely of organic residues are peat and coal, formed from decayed vegetation. *There are numerous peat bogs* *in swampy areas of northern and eastern Manitoba. The largest extends 300 miles near the railway south of Churchill. Other large bogs occur at intervals on either side of the Winnipeg River (32) between Pine Falls and Pointe du Bois. Peat moss is currently produced from the drained Julius bog (33), 45 miles east of Winnipeg. Lignite (low-grade coal) occurs in thin beds at Turtle Mountain in southern Manitoba, where it is interbedded with sandstone and shale.*

Oil-shale and crude oil also result from the decomposition of organic material (mainly marine organisms). *Oil is recovered from depth in the Virden area of southwest Manitoba where it has locally accumulated in porous limestone reservoirs and has been sealed in (or trapped) by overlying impervious shales.*

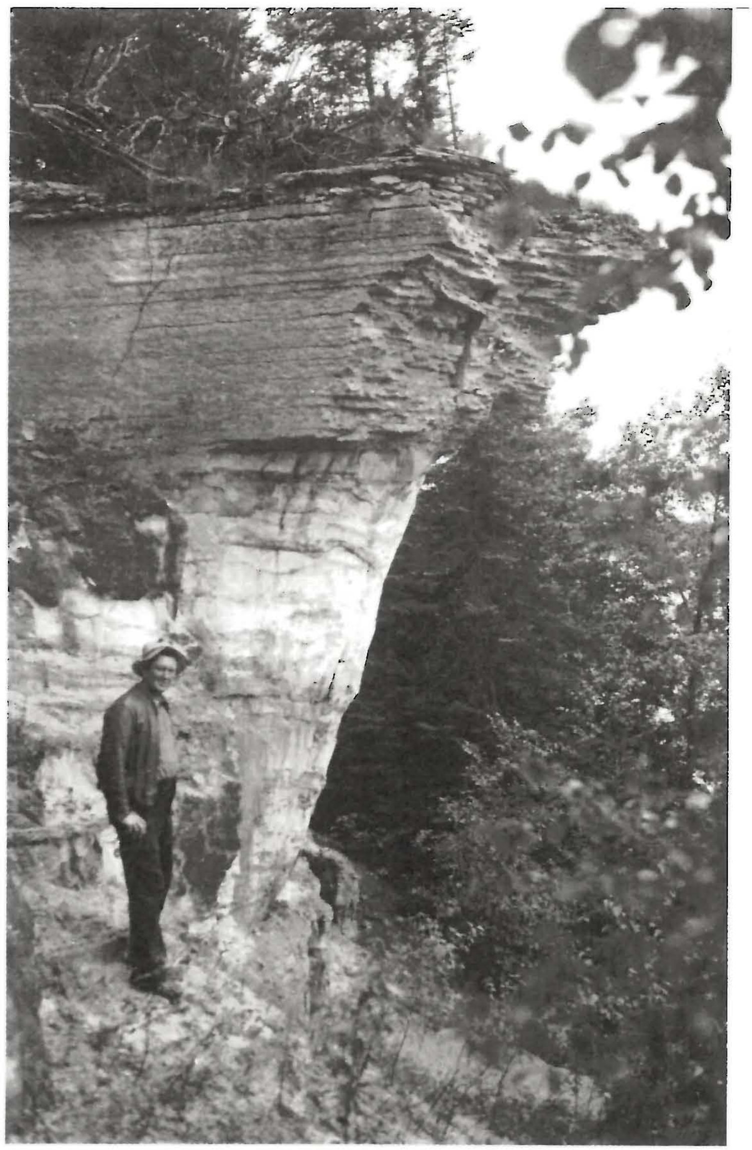


PLATE NO. 29: LIMESTONE overlying sandstone (Grindstone Point)

D. Volcaniclastic rocks

These are volcanic rocks that have been broken mechanically into fragments. Prominent among them are the pyroclastic rocks, which are those formed from the variable clastic fragments hurled out by volcanic explosions. These fragments may consist of lava-bombs (so called from their shape which is due to their hot plastic state when hurled through the air); or of cinders torn from previously cooled lava; or of brecciated volcanic and country rocks broken up during the eruption. Pyroclastic fragments vary greatly in size, from large blocks a foot or more in diameter, down to the finest dust; rounded or irregular fragments of lava somewhere in size between a pea and a walnut are called lapilli (plate 30). Any of these variably sized fragments may be mixed in any proportions, but predominantly coarse pyroclastic rocks are called agglomerate (plate 31) if the fragments are subrounded, or volcanic breccia if they are markedly angular. Not all volcanic breccias are of pyro-

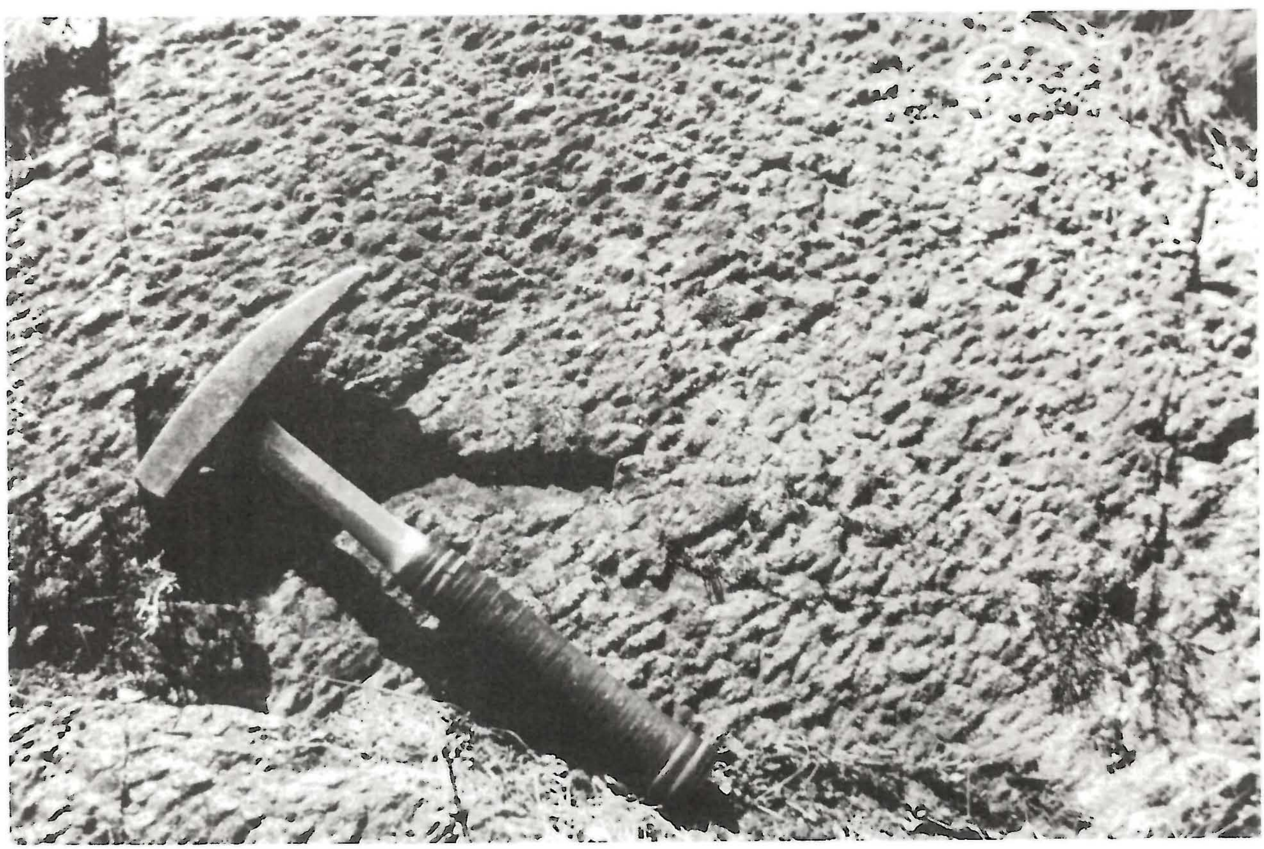


PLATE NO. 30: Outcrop of lapilli TUFF (Beresford Lake) clastic origin however. Some (autoclastic) are formed as a cooling lava flows downhill. Others (epiclastic) are formed by sedimentary processes. The fine to medium grained pyroclastic rocks are called tuffs or, if they are not firmly cemented, ash-beds.

In Manitoba, volcaniclastic rocks are found mainly in or near the greenstone belts. Beds of tuff are abundant in the andesite along the north shore of Falcon Lake (3). At West Hawk Lake, tuff occurs on the north shore and agglomerate on the southwest shore. Again at the nearby Star Lake (3), tuff is found on the northwest shore and agglomerate on the southwest shore. Further north, along provincial road 304, the east end of Wanipigow Lake (23) shows volcanic breccias and tuff-breccias. These rocks also occur at the west end of Long Lake (19) and are accompanied by some crystal tuff at the east end of the lake. The volcanic rocks at Gem Lake (16) are mainly pyroclastic.

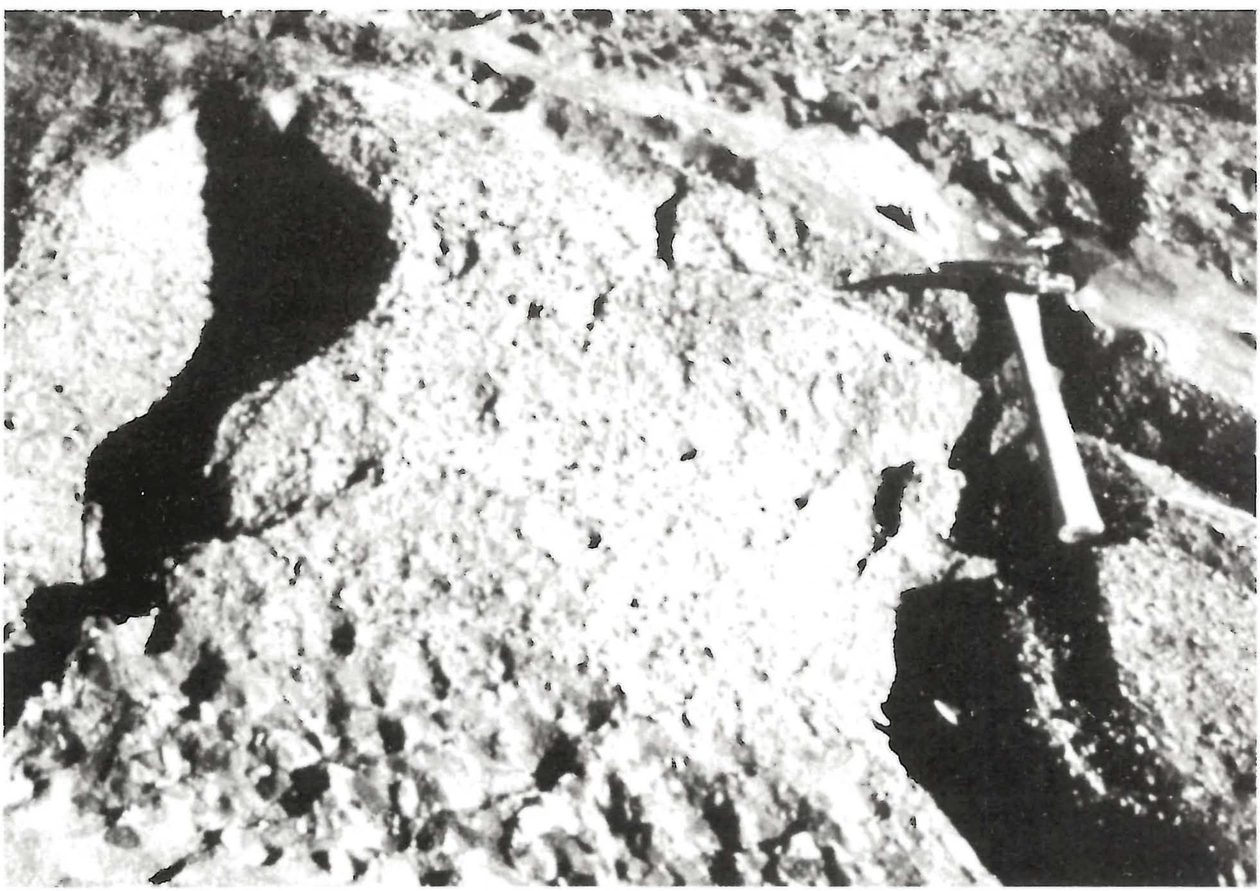


PLATE NO.31: Outcrop of bedded TUFF-AGGLOMERATE (Knee Lake)

E. Metamorphic rocks

Metamorphic rocks can be defined as those which have been altered by heat and/or pressure to such an extent that their original characteristics can no longer be readily observed in the field. Recognition of a heat factor and a pressure factor permits a convenient distinction between the processes of thermal metamorphism and dynamic metamorphism, although in practice most metamorphic rocks have been affected by both.

Sensitive measuring instruments used by seismologists to record earthquakes show that the Earth's crust is constantly undergoing differential movements. Indications of old earthquakes in rocks of all ages are given by great and small fractures known geologically as faults, some of which extend for many miles. The broken and shattered rocks that occur in fault-zones are called fault-breccia. Where crushing has been so intense that the breccia fragments have been ground down to extreme smallness, the resulting rock is called mylonite. The groundmass of mylonite is a hard, brittle, indurated powder of flinty appearance. In simple breccias and mylonites where no new minerals have crystallized, the metamorphic effects are purely dynamic. *Simple fault-breccia is rarely found in Manitoba, because the original breccia fragments have usually been ground down or recrystallized. Some cross-faults are recognized however by displacement of a marker-rock, as in the Bird River sill (10), where segments of the sill have been offset relative to each other. Mylonite is not uncommon in Manitoba, although it may be difficult to recognize without careful studies. Intensive work in the Bissett region has shown a major fault-zone following the north shore of Wanipigow Lake (23), and another extending southeast past the northwest shore of Long Lake (19). Mylonite has been identified along these fault-systems at various localities such as Finger Lake (15), 8 miles southeast of Long Lake.*

In many rocks such as slate (plate 32) and schist (plate 33, colour section), both dynamic and thermal effects can be seen. These rocks split easily into thin sheets (laminae) because they have been sheared. Shearing is a combination of squeezing and dragging movements to which some rocks can adjust by development of slaty cleavage or schistose foliation.* The folia-

* A foliated rock is one in which the platy minerals, especially mica, are aligned parallel to each other.

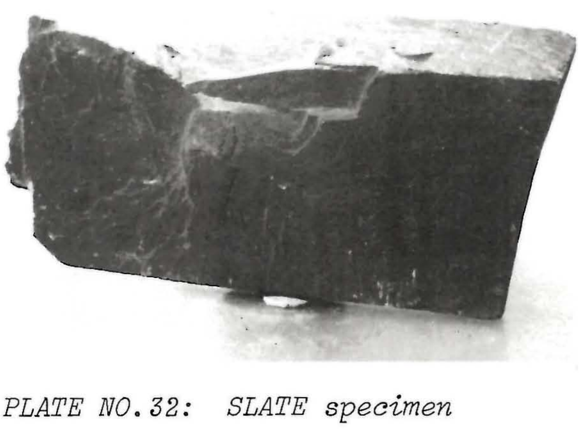


PLATE NO. 32: SLATE specimen

tion of a schist is accompanied by the development of new minerals, especially flat sheets of mica, which grow parallel to the foliation. In a slate there is less recrystallization, but fine-grained mica can be seen under the microscope. *Slate is not uncommon in Manitoba; about a mile south of West Hawk Lake, at the south end of Lyons Lake (3), two or three outcrops of dark grey slate can be seen within the mainly volcanic belt. Schist is abundant in Manitoba, especially in shear zones, which are common around West Hawk and Star Lakes (3). On the west shore of West Hawk Lake, and the north shore of Star Lake, narrow bands of dark mica schist occur in harder metamorphic rocks that are composed mainly of quartz and feldspar. At Flintstone Lake (14) interlayered greywacke and argillite have become partly schistose along the northwest shores. Similar effects can be seen along the south shore of Garner Lake (17). Dark green (chloritic) schists can be found from place to place within the greenstone belts. Basalt near the mylonite zone at Finger Lake (15) has been converted to chlorite schist.*

Rocks in which the metamorphic effects are solely or mainly thermal can be collectively called hornfels or hornstone. These are typically developed in the contact zones around igneous rocks that have been formed at high temperatures; such altered contact zones are known as thermal aureoles. Within these aureoles limestones recrystallize to marble (plate 34, colour section), and sandstones to quartzite (plate 35, colour section). Hornfels that has developed from mudstone, shale or slate is usually described according to the characteristic new minerals that have formed, e.g. garnet hornfels. Rocks of this original composition (argillaceous) are sensitive indicators of thermal metamorphism owing to the readiness with which they develop a variety of metamorphic minerals.

Simple hornfels is not abundant in Manitoba, because many rocks that were once hornfels have been subsequently altered. Rocks of a well defined thermal aureole are exposed however on the north shore of Garner Lake (17). These rocks contain garnet (plate 36) and other minerals formed in the contact zone of the Garner Lake ultramafic intrusion. Marble (i.e. recrystallized limestone) is preserved in only a few areas in Manitoba, one of which is around the southwest shores of Batty Lake, some 15 miles east of Sherridon. The marble is in narrow bands interlayered with quartzite. Outcrops of feldspathic quartzite occur on the east shores of Lac du Bonnet (9) at the mouth of the Bird River (10). The altered sedimentary rocks east and west of West Hawk Lake (3) include some that have been mapped as quartzite, but true quartzites are not abundant here. Good examples of feldspathic quartzite occur on the west shore of Rice Lake (22).

Also important, and very common in the Canadian Shield, are metamorphic rocks of complex origin such as gneisses and migmatites (plates 37, 38). Many gneisses are well banded and many contain the same minerals - feldspar, quartz and mica - that are characteristic of the granitic rocks. In the field they are commonly seen to grade into foliated granite, and elsewhere into mica schist. Hence many gneisses were previously schists that became injected with hot granitic material in a fluid state. The closely associated migmatites are comparable in origin, but they lack the persistent banding of the gneisses and consist of variable mixtures of

PLATE NO. 37: Well banded GNEISS in contact with MIGMATITE (Manigotagan River)

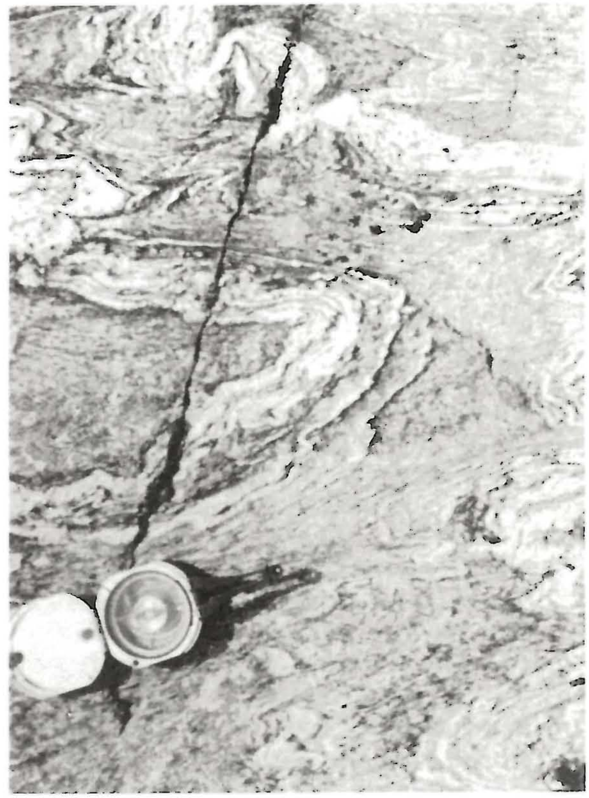


PLATE NO. 38: Contorted GNEISS grading to migmatite (File Lake)

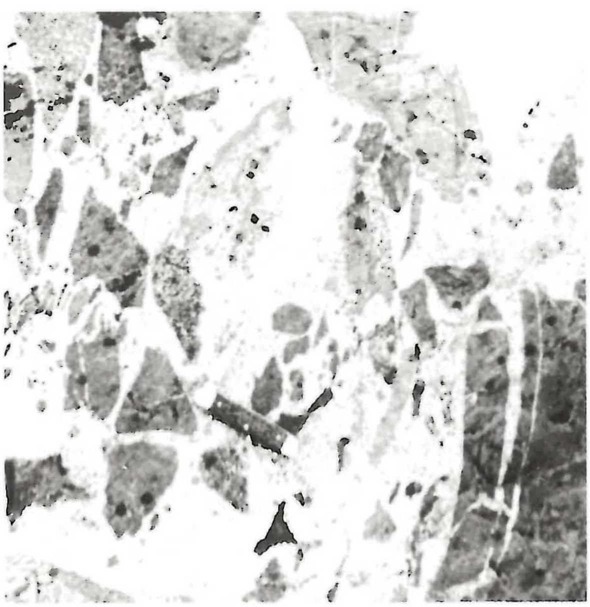


PLATE NO. 39: MIGMATITE with the appearance of breccia (Halfway Lake)

granite with pre-existing (but altered) country rocks (plate 39). Migmatite outcrops are abundant in gneissic terrain, especially near granitic or similar contacts (plate 40).

There are several small outcrops of hornblende-gneiss on the east shore of Lac du Bonnet (9), one mile southwest of the Bird River mouth (10). Similar rocks appear on the northwest shore of Shatford Lake (8). Pegmatitic gneiss is associated with the pegmatitic granite between Greer Lake (4) and the Winnipeg River (32) in the Whiteshell Provincial Park. Some of the granodiorite that is so extensive around the Winnipeg River in this area is gneissic. Paragneisses (those *derived from alteration of sedimentary rocks) are abundant at Manigotagan Lake (20) and Quesnel Lake (21) where they are penetrated by white pegmatite. Gradations from greywacke and argillite to schist and paragneiss can be studied on the northwest shore of Flintstone Lake (14) and the south of Garner Lake (17). For extended studies of a variety of gneisses and associated rocks, the Winnipeg River (32) north of Lac du Bonnet (9) to Lake Winnipeg, and the east shore of Lake Winnipeg show numerous outcrops (plate 41).*

PLATE NO.40: MIGMATITE composed of bands and lenses of white granite set in a grey gneissic groundmass (Lagimodiere Lake)

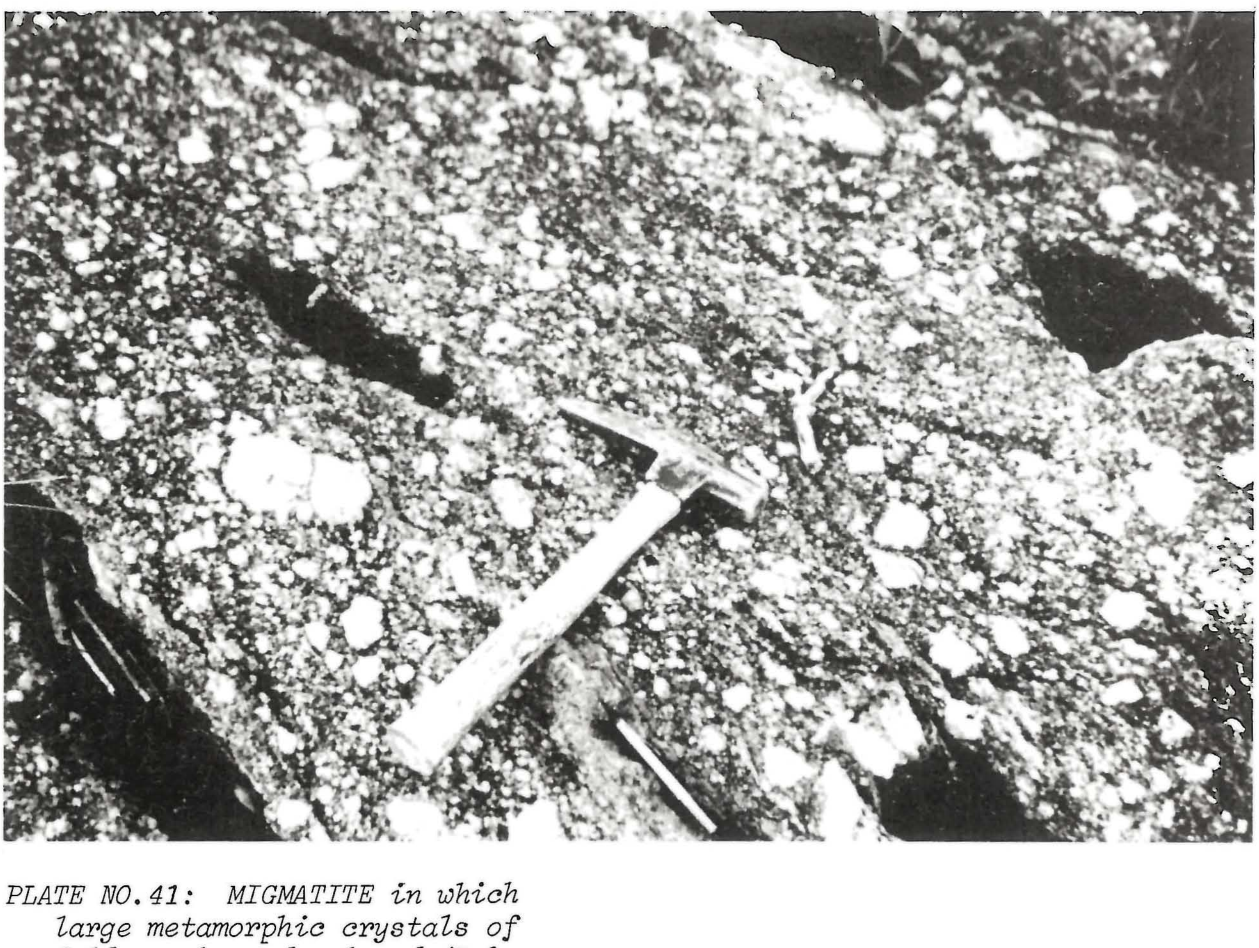


PLATE NO.41: MIGMATITE in which large metamorphic crystals of feldspar have developed (Lake Winnipeg, south of Black River)

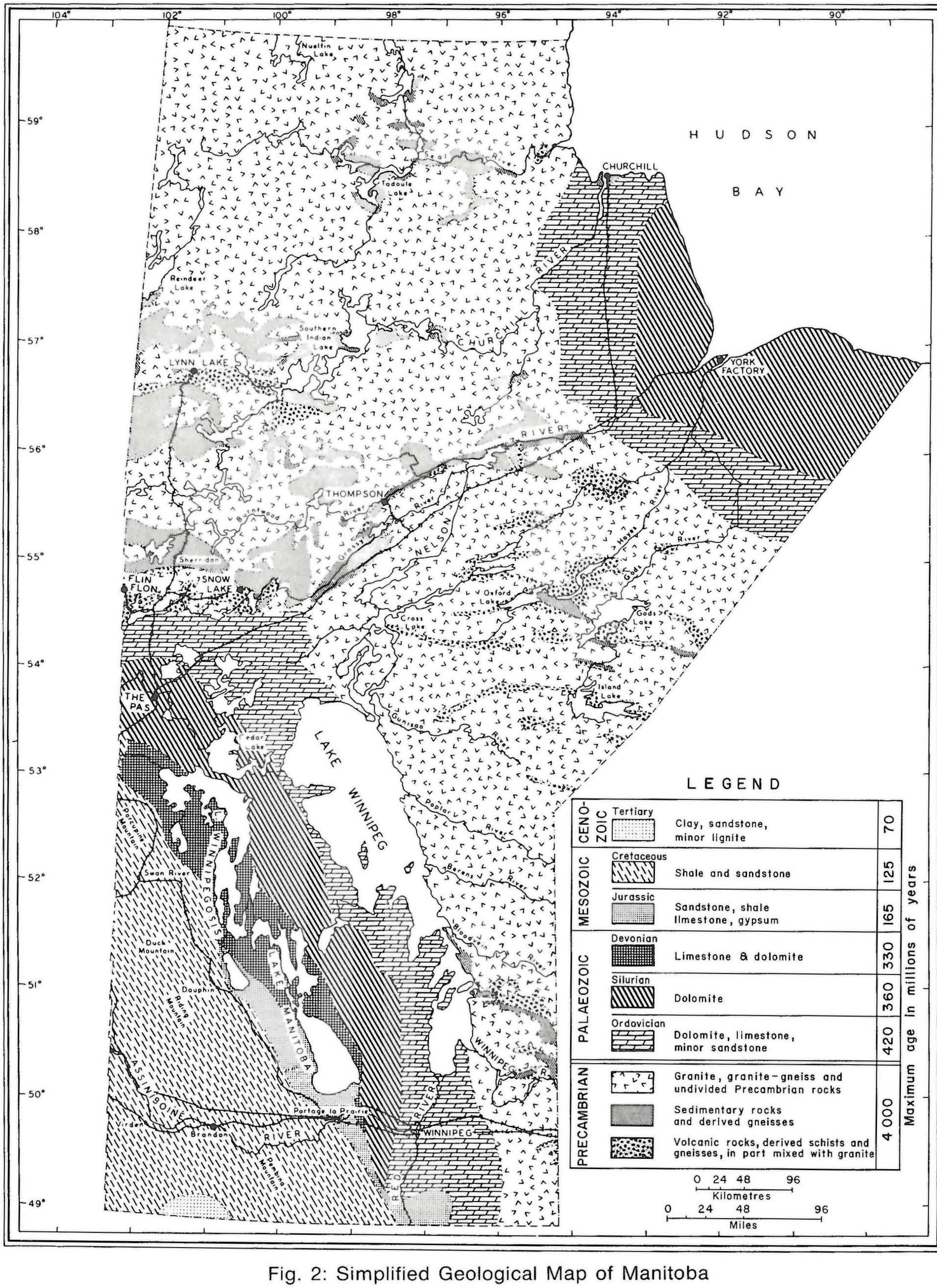


Fig. 2: Simplified Geological Map of Manitoba

F. Rocks of Manitoba

The oldest and most extensive rocks in Manitoba are of Precambrian age and they form part of the Canadian Shield. They are exposed in a broad zone from the southeast to the northwest corners of the Province (fig. 2). This zone includes the Ontario border region as far north as latitude 55°, the Saskatchewan border region as far south as Flin Flon, and the Hudson Bay coastal area north of Churchill. The Precambrian rocks are overlain by younger sedimentary rocks of Palaeozoic age south, west and north of Lake Winnipeg, and also in the Hudson Bay Lowland south and southeast of Churchill. The Palaeozoic rocks are in turn overlain by younger, Mesozoic rocks in the southwest prairie region. The youngest consolidated rocks, of Cenozoic age, are the sandstones and shales of the Turtle Mountain area.

In contrast to the younger rocks which are almost entirely sedimentary, the Shield area shows a great variety of intrusive, volcanic, sedimentary and metamorphic rocks. The Precambrian Shield contains huge areas of granitic and related plutonic rocks with associated gneisses. Such areas are extensive east of Lake Winnipeg and elsewhere. Within these great plutonic-gneissic masses are numerous belts of volcanic and sedimentary rocks, some of which are altered to schist and paragneiss; these belts include "greenstones", formed mainly of andesite, basalt, chloritic schist and hornblende gneiss. The volcanic-sedimentary belts, which are older than the granites, are most extensive in eastern Manitoba, trending east-west through Gods Lake, Oxford Lake and Island Lake. They are of great economic importance in the Flin Flon, Snow Lake, Leaf Rapids and other areas where they contain valuable copper-zinc deposits.

Northwest of the railway line from Dunlop to Gillam, altered sedimentary rocks are much commoner than greenstones. Many of these rocks have been altered to schist, paragneiss, granitized gneiss and migmatite. They occupy large tracts around Sherridon, Nelson House and Thompson, also west of Southern Indian Lake and in the far northwest of Manitoba. Their metamorphism, like that of the greenstones, is connected with the emplacement of the younger granitic plutons.

Mafic to ultramafic intrusions occur from place to place, especially in or near some greenstone belts, but they are rarely more than a few miles in length. Gabbroic intrusions of this scale are quite common around Lynn Lake. Some of the larger bodies occur north of Wanipigow Lake (23), southeast of Cross Lake, west of Reed Lake and east of Sickle Lake. A much larger mafic to ultramafic intrusion - the largest in Manitoba - is the Fox River sill which has a length of about 155 miles, but its outcrops are sparse. Nickel deposits in Manitoba's Nickel Belt are largely associated with ultramafic bodies, but surface outcrops are again quite rare.

The oldest Palaeozoic rocks are Ordovician dolomites and limestones with minor sandstone and shale. These are the rocks that form almost the entire southern, western and northern shore zones of Lake Winnipeg, and extend southward along the Red River valley. Ordovician dolomite overlies the Precambrian Shield east and west of Cranberry Portage, and the dolomite outcrops persist southward to Cormorant Lake. The Ordovician rocks are overlain to the south and southwest by younger dolomites of Silurian age, which occupy most of the Interlake region and are well exposed around Moose and Cedar Lakes and the northeast shores of Lake Winnipegosis. The youngest Palaeozoic rocks are the Devonian limestones and dolomites which form the eastern and northern shores of Lake Manitoba and the more westerly parts of Lake Winnipegosis, including Dawson Bay.

The Mesozoic rocks that overlie the Palaeozoic in the southwest are of Jurassic and Cretaceous age. The Jurassic beds, which include sandstone, shale, limestone and gypsum, surround Dauphin Lake and extend southeasterly along the southwest shore of Lake Manitoba. Overlying them, the Cretaceous shales and sandstones form a prominent escarpment which constitutes the easterly edge of the Porcupine, Duck Mountain and Riding Mountain recreational areas and persists southeast through Morden to the United States border.

Cenozoic shale, clay, sandstone and minor lignite are interbedded in the Turtle Mountain Provincial Park south of Boissevain and Deloraine.

G. Further suggestions

From the foregoing account it can be seen that Manitoba possesses a very wide variety of rocks, which offer great scope for observation by people interested in nature and scenery, as well as those who wish to study rocks in greater detail. The Palaeozoic and younger rocks of the south and southwest provide numerous localities for the study of sedimentary rocks and the collection of fossils. The Precambrian rocks of the north and east show many excellent outcrops of igneous and metamorphic rocks and minerals.

A full understanding of rocks and minerals can only be gained by the study of outcrops in the field, but such studies need the support of prior explanations, and this booklet represents an attempt to partially meet these two requirements at an introductory level. A third requirement is access to selected, identified specimens of rocks, minerals and fossils, to provide a basis of comparison with what is seen in the field. Such specimens can be seen at the Museum of Man and Nature in Winnipeg, and also at the Geology Building of the University of Manitoba. Casual visits at the University may be made Monday to Friday between 9.00 a.m. and 4.30 p.m. Requests for specific information or guided tours can be made through the Secretary of the Earth Sciences Department. Arrangements can also be made under certain circumstances for illustrated lectures, films or talks on subjects of geological interest for organized groups.

Those who wish to collect rock, mineral or fossil specimens as a hobby would do well to establish contact with the Secretary of the Winnipeg Rock and Mineral Club, Inc., P.O.Box 1282, Winnipeg. The club helps arrange visits to places of geological interest for its members, and also provides books and other sources of information, including occasional illustrated talks. The club's annual exhibition in Winnipeg is a notable event, attended by visitors from many parts of the world.

The Geological Survey of Canada has published numerous geological maps, bulletins and memoirs covering most regions of Manitoba. Some of these pre-date the turn of the century. Some recent publications can be purchased from the Government of Canada Bookstore operated by Information Canada at 393 Portage Avenue, Winnipeg.

While the Geological Survey of Canada covered large regions at 4 miles to the inch, the Province of Manitoba has concentrated on more detailed mapping, frequently at 1/2 mile to the inch. The Manitoba Department of Mines, Resources and Environmental Management has thus, since the 1940's, built up a series of geological maps and reports covering many parts of the province.

These provincial publications can be obtained at low cost from the Mineral Resources Division (formerly known as the Mines Branch), presently located at Century Plaza, 993 Century Street, Winnipeg. A free catalogue giving prices of available geological publications can be obtained from this office.

Both the federal and provincial publications attach importance to areas of economic interest in which gold, copper, nickel and many other potentially valuable deposits may occur. This draws attention to practical applications of the study of rocks and minerals: in order to understand what prospecting, mining and quarrying are all about, it is first necessary to understand something about ore-bodies and mineral deposits; these are particular (relatively rare) kinds of rocks and minerals which are studied under the specialized heading of economic geology.

It is hoped that the present booklet will indicate the wide areas of interest that may become open to anyone who begins by asking how to recognize granite, basalt, shale and limestone, and where to look for them in Manitoba.

Written by K. A. Phillips. Designed for publication by B. Carruthers. Photographs of hand specimens by R. Pryhitko Outcrop photographs by B. B. Bannatyne, L. Solkoski and A. H. Bailes; others from various departmental publications.

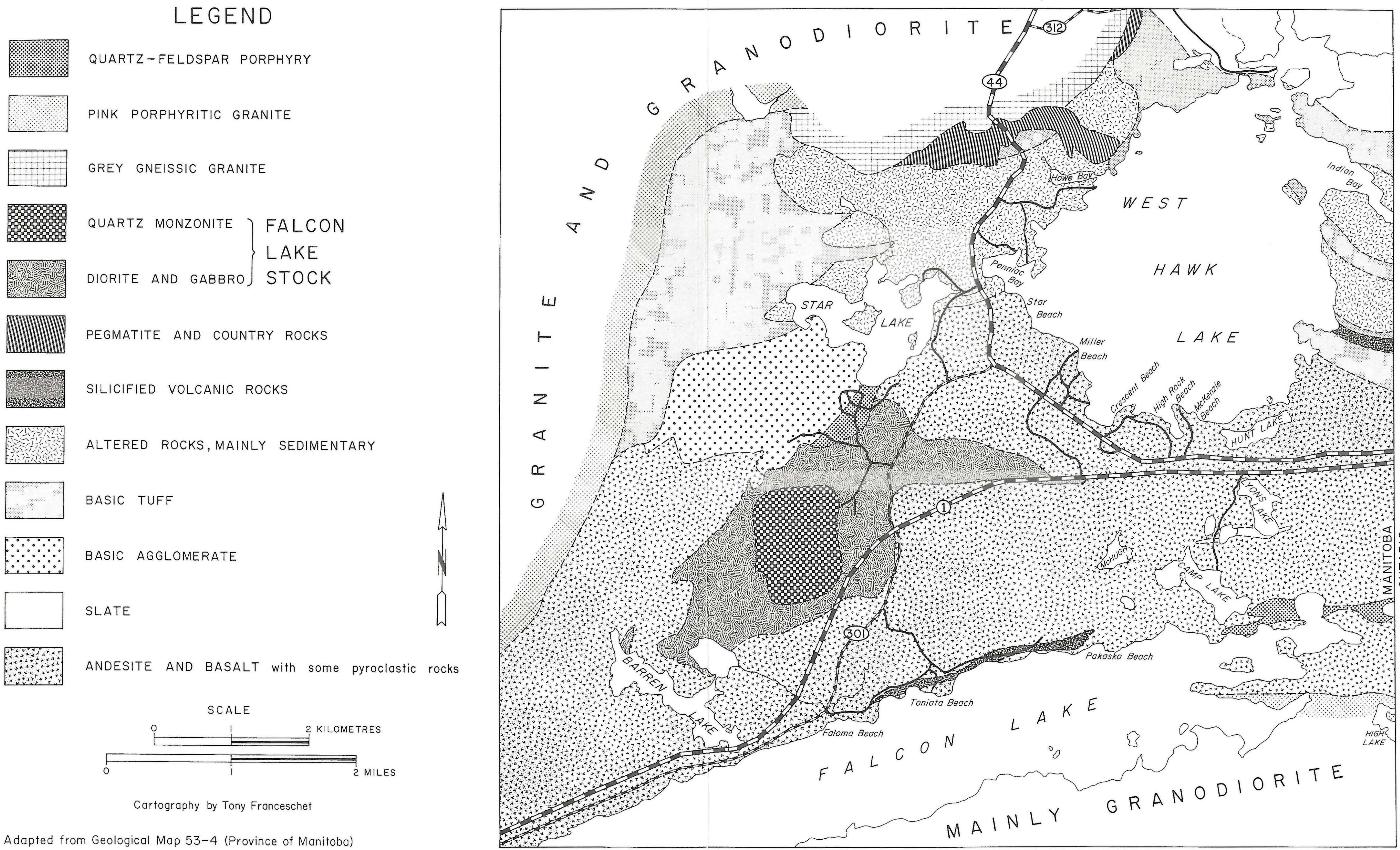


Figure 3: Rocks near West Hawk and Falcon Lake

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