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MALARTIC AREA, QUEBEC

BY

H. C. Gunning and J. W. Ambrose

No. 2454

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Malartic Area, Quebec

CHAPTER I

INTRODUCTION

A detailed examination of a part of the Cadillac gold-bearing belt of northwestern Quebec, begun in 1934, was continued through 1935 and 1936; some supplementary work was done at the mines in Fournière township in 1937. This report deals with the area examined in those years, that is, the east part of Cadillac township, most of Malartic township, and the northern part of Fournière township.

The work of 1934 in Cadillac township showed that the ore deposits occur along a narrow zone of sheared rocks, which was termed the Cadillac belt. In 1935 and 1936 the Cadillac belt was found to continue across Malartic and Fournière townships; the main features of the structure were determined in as much detail as was possible considering the scarcity of outcrops, and sufficient information was obtained to necessitate a revision of the conception of at least the local Keewatin-Timiskaming succession.

Geological mapping was done by two methods: in open country by plane-table surveys, in most cases on a scale of 400 feet to 1 inch; in timbered areas by pace and compass traverses at intervals of 200 feet between surveyed control lines ½ mile apart. All the observations, together with data obtained from mining developments, were compiled on a scale of 1 inch to 1,000 feet.

The accompanying geological maps show, so far as possible, the outlines of the outcrops. However, on forested and moss-covered ridges with numerous outcrops, as on Rubec Mines ground, or the high ridge north of Panamint Gold Syndicate, delineation of individual outcrops would have been an endless task of doubtful value, so that areas of this sort are shown as one large outcrop, even though the drift is sufficient to obscure important geological features such as veins, faults, dykes, or drag-folds.

The Malartic area is part of the LaMotte-Fournière map-area examined by James and Mawdsley in 1925. Earlier work is summarized in their report. H. C. Cooke studied this and adjacent districts from 1923 to 1930, and in 1931 Cooke, James, and Mawdsley collaborated in publishing Memoir 166, a summation of the knowledge of the geology and ore deposits of the Rouyn-Harricanaw region. In 1930 L. V. Bell examined the central part of Cadillac township and in 1934 J. J. O'Neill made a detailed study of the Canadian Malartic mine. The results of Gunning's examination of the Cadillac area in 1934 are available in Memoir 206. As the Cadillac area adjoins the Malartic area on the west, and the geology in the two areas is similar, the present report and Memoir 206 supplement one another.

It is a very real pleasure to acknowledge the many courtesies and the material assistance rendered by practically all those engaged in prospecting and mining in the area. Their helpful, co-operative attitude has not only added materially to whatever value the work may have, but has also converted an otherwise arduous undertaking into a pleasant task. Space prohibits a listing of all the executives, engineers, and others who have lent assistance, but the writers' appreciation is none the less sincere. The following geologists and engineers have been particularly helpful, supplying maps, oral information, and stimulating discussion: L. V. Bell, D. R. Derry, G. F. Flaherty, D. M. Giachino, E. A. Goranson, J. R. Johnston, Th. Koulomzine, W. C. Martin, J. B. Mawdsley, J. J O'Neill, and F. J. Sugden.

A large number of students were employed as labourers and technical assistants; the writers appreciate their cheerful and willing service. Good independent work was done at one time or another by D. H. Cooper, O. Duskes, G. K. Eastwood, M. V. Hodgins, N. F. Jefferson, I. F. MacIntosh, R. Parkinson, J. D. Rice, M. Scott, L. G. Smith, and H. L. Umphrey.

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GENERAL GEOLOGY

The sedimentary and volcanic rocks of Malartic area are all of early Precambrian age and are subdivided into four main groups (*See* Figure 1). The nomenclature used is a modification of that adopted by Gunning for the adjoining Cadillac area. He divided the rocks there into six lithologic units pending the accumulation of more data concerning the regional structure. Subsequent work has proved that the strata are folded into an isoclinal syncline as he had suggested, and correlation of the members forming the limbs is now possible. The Malartic group consists of the volcanic rocks that in the Cadillac area were named the Malartic volcanics; the Kewagama sediments and the Fournière sediments of the

Cadillac area have been correlated and now are termed the Kewagama group. Similarly, the Blake River volcanics and the Cadillac belt of volcanics are correlated and now are named the Blake River group. The Cadillac sediments now become the Cadillac group.

Table of Formations

Cenozoic	
Recent and Pleistocene:	Clay, sand, and gravel.
Proterozoic (Late Precambrian)?	
	Quartz diabase dykes.
Archæan (Early Precambrian)	
	Granite, syenite, and related porphyries; aplite, albitite granodiorite, serpentine (peridotite?) dykes, and small bodies of gabbro, diorite, and amphibolite.
Cadillac group:	Greywacke, conglomerate, quartzite, iron formation, some beds of tuff, and agglomerate; mica, chlorite, and hornblende schists.
Blake River group:	Altered, basic to acidic lavas and pyroclastics; associated diorite dykes; minor amounts of greywacke and conglomerate; schists.
Kewagama group:	Greywacke, tuffaceous greywacke, schist; some conglomerate at base.
Malartic group:	Altered, basic to acidic lavas and pyroclastics; associated diorite dykes; some interbedded tuff, slaty greywacke, and conglomerate; schist.

The oldest of these, the Malartic group, consists of an unknown thickness of extrusive rocks with one major intercalation of sediments. The group was classified as Keewatin by James and Mawdsley (1925, page 58). It is overlain by the Kewagama group of sedimentary rocks, 1,000 to 2,500 feet thick in the northern part but of unknown thickness in the southern part of the area. These sedimentary rocks in turn are overlain by the predominantly volcanic Blake River group, exposed in two subparallel bands on opposite limbs of the major synclinal structure. The northern band varies in width from 700 to 2,500 feet, the southern from less than 200 to about 3,000. The southern band, commonly called the Cadillac belt, includes a zone or zones of intense shearing that continue westward across Cadillac township; along or near it lie all the important mines of the Cadillac-Malartic area. The name Cadillac Break has been applied to this zone of shearing. The Cadillac group of sedimentary rocks is the youngest of the four; it has a maximum thickness of at least 5,000 feet and forms a central synclinal trough across the whole area.

The volcanic and sedimentary strata are intruded by several varieties of igneous rocks. Dykes of diorite are almost entirely restricted to the Malartic and Blake River groups and dykes of serpentine were found only in the Malartic volcanic rocks. A thick, sill-like body of granodiorite along the south shore of Malartic Lake is possibly one of the oldest acidic intrusives. Several small granitic and syenitic stocks and innumerable acidic dykes are the latest Archæan rocks. A few dykes of Keweenawan (?) diabase complete the igneous sequence.

More than 80 per cent of the area is covered by Recent alluvium and Pleistocene deposits of unsorted drift, varved clays, sand, and gravel. There is a dense forest growth except in areas that have been cleared or burned.

THE TIMISKAMING-KEEWATIN PROBLEM

The three groups above the Malartic volcanic rocks were included in the Timiskaming by James and Mawdsley, but they recognized that this grouping, including as it did wide bands of Keewatin-like volcanic rocks in the Timiskaming sediments, was not satisfactory. However, they discovered no angular unconformities and, without adequate structural observations, were forced to consider the whole series a homoclinal succession with progressively younger strata toward the south. They, therefore, concluded that there was a gradational change from volcanism to sedimentation, and arbitrarily drew the dividing line between the Keewatin and the Timiskaming at the base of the dominantly sedimentary series.

In the section of this report dealing with structure evidence is presented to show that these rocks lie in a syncline and not in a homocline. Instead of the strata being progressively younger to the south, the youngest are the Cadillac group and the beds north and south of these are older and lie on opposite limbs of the major syncline. Furthermore, no evidence has been found of unconformity between any of the different groups of rocks. Therefore, if the generally accepted subdivision into Keewatin and Timiskaming is to be retained, some serious problems arise.

If James and Mawdsley's original (1925) subdivision be accepted the Malartic group is Keewatin and all the strata to the south Timiskaming. That is, the Cadillac, Blake River, and Kewagama groups constitute a threefold subdivision of the Timiskaming; the three groups are, respectively, sedimentary, volcanic, and sedimentary, and have a total thickness of not less than 11,000 feet. This mode of subdividing the strata was unsatisfactory and was discarded by Cooke, James, and Mawdsley in Memoir 166 and the accompanying Map 271A, issued in 1931. On the part of Map 271A representing Malartic area, the attempt was made to draw a line that would separate what was an assemblage consisting essentially of volcanic rocks, that is the Keewatin, from another assemblage to the south consisting essentially of sedimentary rocks, that is the Timiskaming. In places this line corresponds with what is now known to be the north edge of the area occupied by the Cadillac group. Elsewhere because of lack of precise information at the time Map 271A was being prepared, the boundary line lies farther north. The authors of Map 271A intended to include in the Keewatin the Malartic group and the northern bands of the Kewagama and Blake River groups. Their Timiskaming was to include the Cadillac group, the southern band of Blake River volcanic rocks, and the southern area of the Kewagama sedimentary group. The inclusion in the Keewatin of the northern band of the Blake River volcanic rocks was a much happier solution of the problem, for these rocks continue westward from Cadillac township over a large area where they have long been called Keewatin. To place them in the Timiskaming would undoubtedly prove very confusing. According to the authors of Memoir 166 the continuation of the northern band of the Kewagama group (the Clericy sedimentary band), tentatively considered to be Timiskaming, occupied a synclinal

trough in older volcanic rocks. Fuller evidence now available does not support this idea of the structure, but definitely indicates that these sediments are interbedded between an older (Malartic group) and a younger (Blake River group) volcanic assemblage. In a later edition of Map 271A, published in 1936 and known as 328A, the general succession and structure were left unchanged except that the Clericy sedimentary band was assigned to the Keewatin with the proviso that it might be post-Keewatin.

The detailed work of the past several years has furnished no evidence of an angular discordance or of an erosion interval that would indicate a definite subdivision of the Archæan strata into two series that might appropriately be termed Keewatin and Timiskaming. Elsewhere in western Quebec and neighbouring parts of Ontario the Keewatin has generally been considered to be an early division of the Archæan, composed mainly of volcanic rocks but with some interbedded sedimentary materials that in places form thick series. The Timiskaming, on the other hand, has usually been defined as being essentially a thick clastic assemblage, in places accompanied by volcanic rocks, having a basal, conglomerate member holding fragments of granite and of the many kinds of rocks found in the Keewatin. Direct and indirect evidence has been offered to show that the Timiskaming strata are unconformable upon the Keewatin, were laid down after a long interval during which the Keewatin was folded, invaded by granite batholiths, and subjected to deep erosion that in part unroofed the batholiths.

In Malartic and adjoining areas no evidence has been found warranting the division of the strata into a Keewatin series and a Timiskaming series. Possibly the Cadillac group represents the Timiskaming. It contains the abundant conglomerate usually considered typical of the Timiskaming elsewhere in Ontario and Quebec. If the Cadillac group does represent the Timiskaming it then follows that the bulk of the sediments formerly classed as Timiskaming, as they belong to the Kewagama group, are pre-Timiskaming and, therefore, presumably Keewatin. It is worthy of note that whether the major structure of the area is or is not synclinal, the difficulties in the way of employing the terms Timiskaming and Keewatin remain practically the same. For the present it seems inadvisable to separate the strata into Keewatin and Timiskaming divisions.

NOMENCLATURE OF THE VOLCANIC ROCKS

A precise petrographic classification of the volcanic rocks is practically impossible, for they are all more or less altered to secondary minerals. Some two score thin sections of them have been examined, and the broad results of this work are incorporated in the section on metamorphism. There is no need to burden the reader with the details, as they are similar to those given in many earlier reports. All the volcanic rocks in the area, with the exception of some of the rhyolites, are so highly altered that it is impossible to be sure of their original composition. Quartz appears to be the least changed of the principal components, but much of it may be secondary; certainly many quartz grains have been enlarged during alteration. The intermediate to basic members, the familiar "greenstones", are usually a confused mass of hornblende,

chlorite, carbonate, mica, and epidote or clinozoisite with little or no feldspar remaining. Where feldspar does persist it is commonly in such small grains or so highly charged with impurities as to prohibit precise identification. When the feldspar is identifiable it is nearly always sodic albite whether the rock is classified in the field as basalt, andesite, dacite, or rhyolite. A few of the notable exceptions are indicated in the section on metamorphism. The acidic members appear fresher and less altered except where intensely sheared, the ordinary secondary minerals being white mica, carbonate, pale biotite, chlorite, and epidote or clinozoisite. As in the more basic varieties, however, the feldspar is nearly always sodic albite. Two exception are worthy of note. A sheared porphyritic rhyolite in Cadillac township from the True Fissure property, collected near the south side of the Blake River group, consists of about 25 per cent zoned plagioclase, which ranges from albite (An_2) to oligoclase (An_{20}), as well as quartz phenocrysts and the usual accessories. In an adjoining, massive, porphyritic phase of the same rock the feldspar is practically pure albite. A rhyolitic lava from lot 15, range VI, Malartic township, near the south edge of the Malartic group, has about 65 per cent of oligoclase (An_{14}) charged with finely divided sericite and epidote, and contains, besides quartz, the usual accessories.

The microscopic work clearly indicates that the present mineralogical composition is not the original composition of the volcanic rocks. It is impossible to believe that albite was the predominant feldspar in rocks that ranged from very basic to very acidic types. Therefore, at least in the more basic varieties, and probably in all, the original feldspar has been albitized. If one assumes that albitization occurred soon after the lavas solidified, the rocks should be classified as spilites or members of the spilitic suite of British petrologists.[1] The facts that the sediments of the Cadillac group and the later intrusives are also unusually rich in albite, and that the potash feldspar of some of the intrusives is clearly replaced by albite, suggest that albitization may have taken place long after the deposition of the volcanic rocks. If, as seems probable, albitization is a product of much later metamorphism, little can be done about a more precise nomenclature of the volcanic rocks than to combine the available microscopic and megascopic evidence and arrive at some reasonable compromise. Accordingly, the names in common use have about the following meanings.

Basalt: dark green to black lavas, quartz-free and rich in ferromagnesian constituents.

Andesite: green, quartz-free lavas, moderately rich in ferromagnesian minerals and feldspar.

Dacite: pale green to grey lavas, with a small amount of quartz.

Trachyte: quartz-free, feldspathic, pale grey to white lavas.

Rhyolite: generally light-coloured, but occasionally dark grey or black, and commonly porphyritic lavas with much quartz.

Greenstone: a general term that usually applies to andesite or basalt, but may include dacite and altered agglomerates and tuffs of intermediate to basic composition.

[1] Dewey, H., and Flett, J. S.: Geol. Mag., vol. 8, 1911, pp. 202-209.

MALARTIC GROUP

GENERAL DESCRIPTION

The Malartic group is an assemblage of lavas, volcanic fragmental rocks, and some sediments that outcrops across widths of 1 to 3½ miles along the northern edge of the area. Similar rocks extend far beyond the mapped area to the north and northeast, so that the northern limit of the group is not defined. The southern limit is the contact with the overlying Kewagama sediments. In Cadillac township the strata strike nearly due east, but just west of Malartic township they curve to 35 degrees south of east, and this strike persists, with local deviations, to the eastern limit of the area. The dip is uniformly very steep, commonly vertical, so that the exposed width is but little greater than the actual thickness. A maximum mapped width is about 18,000 feet. In one section where outcrops are practically continuous and many structural determinations indicate that the tops of all beds and flows face south, a thickness of at least 7,000 feet is indicated. On an additional 2,500 feet of volcanic rocks to the north no determinations of top were made. Another section shows a thickness of 10,000 feet. These must be regarded as absolute minima. As the bottom of the group is unknown, the total thickness may be much greater.

The volcanic rocks of the Malartic group are predominantly of intermediate composition, i.e., andesite and dacite. Basalt is uncommon and rhyolite is abundant only in the upper part of the group. Trachyte is uncommon. Lava flows are much more abundant than fragmental types. The andesitic and dacitic flows frequently exhibit pillow structure, and in places a fair columnar jointing is preserved. Many pillowed flows and some massive flows are amygdaloidal. Brecciated flow tops are not uncommon, and seams and irregular blotches of epidote are common. Individual flows range in thickness from a few feet to about 200 feet. No greater widths were determined, but may occur; the majority are between 20 and 100 feet. Andesite and dacite vary from dense, aphanitic rocks to porphyries with phenocrysts of feldspar or hornblende, and holocrystalline types of dioritic appearance.

One of the most difficult problems is to distinguish, in areas of poor outcrop, between intrusive diorites and coarsely crystalline andesitic flows. The problem is discussed at greater length in the section on intrusives. In areas of Malartic volcanic rocks, and to a lesser extent of the Blake River group, it is often quite impossible to be sure whether an exposure is intrusive diorite or merely a coarse-grained phase of a flow. Most such exposures have been represented on the maps as lava, as it was deemed preferable to err in that direction rather than to indicate as dykes exposures that might be parts of flows.

Rhyolite is dense, almost cherty, to porphyritic, with phenocrysts of quartz or feldspar or both minerals. Some varieties, probably gradational to trachyte or dacite, are pillowed and amygdaloidal.

Fragmental volcanics include tuffs, agglomerates, and flow breccias. These rocks are interbedded with flows throughout the part of the group examined, but are most abundant in the upper half. Agglomerate forms beds and irregular unsorted deposits 100 feet or more thick and consists

of fragments of andesite or rhyolite ranging up to 5 or 6 feet in diameter in a fine-grained, chloritic to sericitic matrix. About the middle of lot 17, range VII, Malartic township, there are several beds of andesitic agglomerate, from 15 to 30 feet thick, that grade from agglomerate with fragments a foot or more in diameter on the bottom to fine-grained, chloritic tuff on the top. Thin layers of bedded tuff, mostly of acidic composition and grey to pale green, are very useful for determination of strike and dip in the volcanic assemblage.

The following section of the Malartic strata exposed in lots 15 to 22, ranges VI and VII, Malartic township, illustrates the nature of the group in one well-exposed area, but is not typical of the whole group, for sections taken at other localities vary considerably. The section is given in descending order commencing at the contact with a thin bed of conglomerate at the base of the Kewagama group.

	Thickness Feet
Breccia grading upwards to conglomeratic breccia and conglomerate..	160
Dioritic to gabbroic flow	100
Rhyolitic, pillowed in part; thickens to west	50-300
Andesitic lava	250
Nodular, rhyolitic lavas; cut by swarms of dykes of feldspar porphyry.	700
Dioritic to andesitic lava, one layer of pillows near top; possibly two or more flows	450
Dioritic lava	220
Basaltic to andesitic flow	200
Breccia	130
Andesitic flow	350
Quartz diorite, intrusive, 360 feet broad	
Dense, green, andesitic lava	1,320
Pillow lava underlain by andesite	
Dacitic to andesitic greenstone with several pillowed layers, some thin beds of breccia, all cut by numerous dykes of feldspar porphyry..	
Serpentine dyke, 50 feet broad	
Highly altered pillow lava	50
Serpentine dyke, 250 feet broad	
Dense porcellanite, 30 feet broad	
Pillowed andesite	1,400
Dioritic lava	
Pillowed lava	
Greenstone	
Andesitic to basaltic, massive greenstones	
Pillowed andesite	
Andesitic to basaltic greenstones	
Breccia	
Pillowed greenstone	
Contorted and banded greenstone with some breccia	
Dioritic greenstone	
Covered	550
Greenstone with epidote lumps	520
Dioritic lava	
Greenstone	
Conglomerate, some tuff and breccia	340±
Tuffaceous greywacke	180±
Granodiorite sill, 1,700 feet thick	
Dacitic to andesitic lavas, relative age unknown	700±
	7,600±

NODULAR FLOWS

The uniform character of the volcanics makes it impossible in a country of small, scattered outcrops to follow any chosen flow beyond the limits of an exposure. There is, however, one persistent zone, 200 to 700 feet wide, within which are a large number of nodular dacites and rhyolites of distinctive appearance. In Malartic township the zone can be followed by a series of discontinuous exposures from the middle of lot 13, range VI, to lot 36, range IV, or for about 5 miles. Many types of lava in this zone are identical in appearance with the spherulitic lava horizon of the Porcupine area, and it is of interest to note that in both places the lava constitutes a valuable horizon marker[1].

These nodular rocks are strikingly different from the common lavas. The nodules, set in a matrix of greenish grey, fine-grained, dacitic or rhyolitic lava, are of siliceous material, have a dense, cherty grain, and weather somewhat lighter grey than the matrix. Most of them are shaped like flattened cigars, all are oriented with their long axes vertical, and in places are so tightly packed that the slightly schistose matrix is reduced to thin films. The cigar-shaped bodies range from 1 to 6 inches long, ¼ inch to 1½ inches wide, and ⅛ to 1 inch thick; some of them are flattened to thin ribbons paralleling the planes of schistosity. On weathered surfaces the oval cross-sections project ⅛ inch or so in sharp relief. Poorly developed radial and concentric structure can be detected on the weathered ends of some.

The nodules are composed of grains of quartz and albite 0·001 to 0·002 mm. in diameter, finely divided epidote, tiny flakes of chlorite and deep brown biotite, wisps of greenish blue amphibole, and a few grains of magnetite. The matrix in which the nodules are set is made up of the same minerals, but is coarser in grain (quartz, 0·02 mm. diameter), has little biotite, less quartz than the nodules, and more epidote, amphibole, and chlorite. In a few nodules examined in thin section there is a tendency towards segregation of the minerals, with chlorite and amphibole most abundant around the peripheries and with quartz and albite concentrated in the centres.

Distribution of the nodules within the flows seems capricious. Some flows 20 feet thick have nodules from top to bottom; one flow with nodules abundant from top to bottom was traced for ½ mile and has a thickness that decreases from 80 feet to 30 feet; others carry scattered groups with indefinite boundaries; one flow with numerous nodules at one end of an exposure passes along the strike in a short distance into apparently massive uniform dacite.

A few of these peculiar flows have well-developed pillow structure, and these give one of the best clues to the origin of the nodules. In several of the pillows examined the nodules are arranged in fairly well-defined layers concentric with the outlines of the pillows; no nodules occur in the interpillow material. Those in the outer layers are tiny, mostly less than ⅛ inch wide; in the centres of the pillows they are consistently much larger, though most are less than an inch wide.

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1 Burrows, A. G.: "The Porcupine Gold Area"; Ont. Dept. of Mines, vol. 33, pt. II, 1924, p. 16. Hurst, M. E.: "Recent Studies in the Porcupine Area"; Trans., Can. Inst. Min. Met., vol. 39, pp. 448-458.

Previously these nodular flows have been described as spherulitic lavas, but the evidence cited above indicates that the nodules are not spherulites but instead are squeezed amygdules. The growth of spherulites depends mainly upon rapid chilling of the lava, and roughly speaking the more rapid the chilling the larger the spherulites. Accordingly, in pillows, the largest spherulites should develop near the outside, and the size should decrease towards the middle. The size distribution of the nodules is the exact reverse of this, but is understandable if the nodules are amygdules, for the gas-filled cavities, later filled with secondary minerals, would be smallest near the chilled margins and largest towards the centres of the pillows. Similarly, the size and distribution of spherulites might be expected to show some relationship to the margins of the flows, but neither the size nor the distribution of the nodules seems to be affected by proximity to the margin. The patchy distribution of the nodules in some of the flows, and the passage along the strike of nodular into massive flows can only be accounted for by assuming that the amounts of gases that developed as the lavas cooled differed from place to place. The mineralogy of the nodules affords little evidence either for spherulitic or amygdaloidal origin, for all the minerals are secondary.

PYROCLASTICS IN RANGE III, MALARTIC TOWNSHIP

In lots 37 to 41, range III, a series of pyroclastics attain a thickness of some 2,000 feet. There is some doubt whether this thick assemblage should be included with the Malartic group or with the Kewagama group. The rocks range from fine-grained, well-sorted and well-bedded tuffs to coarse, unsorted breccias containing angular blocks 3 or 4 feet long. The water-lain tuffs are in beds ½ inch to 6 inches thick; dark grey when fresh, they weather light greenish grey and greatly resemble some varieties of greywacke. Tiny plates of biotite can be distinguished in a matrix of finely divided felsic material. The main constituents, in order of decreasing abundance, are colourless epidote and clinozoisite, albite, pale brown biotite, quartz, and carbonate. In addition, there are varying amounts of tremolitic amphibole, chlorite, leucoxene, and disseminated pyrite. The minerals, as shown by mutual inclusion and sieve texture, are all secondary.

Coarser grained varieties, ranging from coarse tuffs to breccias with fragments ½ inch in size, form the great bulk of the series. The fragments are of three closely related rock types; aphanitic felsite, in part pumiceous, quartz-feldspar porphyry, and feldspar porphyry, all probably having the composition of dacite or quartz andesite. The coarser varieties are mostly poorly sorted and bedded, and, except in the few places where fine tuffs are interbedded, the rock is so massive that structural observations are impossible. Still coarser breccias, with fragments to 3 or 4 feet long, are common. In some the fragments are distinctly rounded, but the presence of only the three above mentioned varieties of rock distinguishes these breccias from normal conglomerates.

A feature that assists in determining the pyroclastic origin of this series of beds is the common occurrence of sharply angular fragments 3 to 18 inches long, scattered at random through even the finest grained and best bedded tuffs. Their uniformity in petrographic type, unrounded out-

lines, and random distribution, all suggest that they were produced by explosions and fell into the beds of finer material.

The exact thickness of this series of pyroclastics is unknown. The width of outcrop across the regional strike is 3,000 feet, but the few reliable observations of attitude show that the beds are folded, and the thickness, certainly less than the outcrop width, may not be over 1,500 feet.

These rocks, although in part laid down in water, are very different in appearance, composition, and mode of origin from the normal sedimentary rocks of the Kewagama group. As they record the final phases of early igneous activity they are included with the Malartic volcanic rocks.

SEDIMENTARY ROCKS

The only noteworthy mass of sedimentary rocks within the Malartic group is exposed in lots 20 and 21, range VII, Malartic township, where a thickness of about 400 feet of conglomerate is bordered on the north by at least 100 feet of fine-grained, banded, arkosic to argillaceous strata, in part altered to mica schist. The exact thickness cannot be determined as the north edge of the sediment is drift-covered. The conglomerate grades southward into dacitic agglomerate and lava and the contact is difficult to establish. Interbedded with the conglomerate are fine-grained, grey to greenish, siliceous beds interpreted as being tuff, greywacke, and, possibly, rhyolitic lava, all in large part converted to quartz-sericite schist. The conglomerate is a grey-weathering, siliceous rock with scattered layers and groups of angular to rounded, felsitic pebbles, up to about one foot in diameter. The total length of the exposures is only 1,500 feet.

There can be no doubt of the strictly conformable relation between the sediments and the volcanic rocks to the south. Lacking any exposures at the northern contact, the occurrence is interpreted as evidence of a short period of sedimentation during the otherwise continuous period of volcanism that formed the rocks of the Malartic group. Much of the sedimentary material is identical in appearance and composition with that of the younger sedimentary groups that lie to the south.

RELATIONS OF THE MALARTIC GROUP TO THE KEWAGAMA GROUP

The contact between these two groups was formerly considered to be the Keewatin-Timiskaming contact. James and Mawdsley concluded that the succession was conformable, and stated, "the change from essentially volcanic conditions (Keewatin) to mainly sedimentary conditions (Timiskaming) took place without folding of the older series as in other localities to the west in Ontario and Quebec." This conclusion has been fully confirmed by the later detailed work. The attitudes of the flows are parallel to the attitudes of the overlying beds of the Kewagama group from one end of the area to the other. Certainly no major period of folding intervened between the close of the early volcanism and the beginning of sedimentation.

Some minor discrepancies do appear in the attitudes of the volcanic rocks adjacent to the contact. Thus, the thick series of pyroclastics described above apparently pinches out in less than ½ mile to the southeast

and in not over 1½ miles to the northwest. Again, a dioritic flow, exposed for 1,000 feet in lots 14 and 15, range VI, if projected westward according to its strike of north 60 degrees west would intersect the contact at an angle of 30 degrees. Unfortunately, exposures are lacking in the critical area; the dioritic flow, hidden under drift, may swing into accordance with the contact, or hidden minor faulting may account for the discrepancy in strikes.

The contact between the two groups is exposed in only five places in a distance of 15 miles, and in none of these is it exposed for a length of more than a few feet. In the westernmost exposure, in the True Fissure property, the contact is poorly exposed over a distance of 250 feet. There, fine- to coarse-grained andesite and fine-grained agglomerate or conglomerate are conformably succeeded on the south by a mixture of greywacke and agglomerate or conglomerate. In one locality the succession from north to south is: 27 feet of moderately schistose, amygdaloidal to dense, green andesite; 15 feet of conglomerate; 1 foot of greenish grey, tuffaceous, sedimentary rock. Pebbles in the conglomerate are irregular to oval and attain sizes of 2 by 6 inches. They consist of porphyritic andesite and grey, sedimentary rock, and lie in a schistose, grey, banded, clastic matrix. Two hundred feet west the succession from north to south is: 12 feet of moderately schistose, medium-grained andesite; 3½ feet of sheared agglomerate (?) with disk-shaped fragments of medium-grained andesite and greywacke and a few tiny lenses of greywacke at the top; 12 to 18 inches of fine-grained agglomerate with small, white, felsitic fragments; 6 inches of argillaceous sediment; 1 to 3 feet of conglomerate or agglomerate with felsitic fragments not over ½ inch in diameter; 2 or 3 feet of moderately coarse, normal greywacke; 40 feet of drift-covered ground followed by large exposures of normal greywacke. The presence of many volcanic fragments throughout the coarse clastics accounts for the difficulty in distinguishing agglomerate from conglomerate. All the beds are conformable, and apparently there is a gradual passage from volcanic to sedimentary rocks.

On Central Malartic property, lot 13, range VI, Malartic township, a trench across the contact exposes the following succession: 5 feet of dense andesite; 30 feet of conglomerate cut by several dykes of albite porphyry; 16 feet of coarse-grained biotitic greywacke cut by dykes of albite porphyry. Pebbles in the conglomerate are well rounded to angular and range up to 6 inches in diameter; they are of felsite, fine-grained diorite, and massive andesite, and are set in a greenish, coarse-grained matrix. The attitude of the andesite could not be determined, but the attitudes of nearby flows are conformable with the contact and with the bedding in the overlying sedimentary rocks.

In lot 15, range VI, Malartic township, sections across the contact are exposed in one or two places. One, from north to south, is as follows: 75 feet of rhyolite and andesite breccia; 100 feet of drift; 15 feet of dense, bedded, andesite tuff; 35 feet of dense, greenish grey, chloritic greywacke. Bedding is conformable throughout. Two hundred to 400 feet southeast the succession is as follows: 10 feet of grey, acidic breccia; 50 feet of green, bedded tuff; 60 feet of bedded, argillaceous to siliceous, sedimentary rocks, with good crossbedding that indicates that the beds face southwest; 40 feet of agglomerate and poorly sorted conglomerate; 150 feet of drift; 75 feet of normal greywacke. Most of the angular to subangular fragments

in the conglomerate and agglomerate are of felsite and aplite, a few are of green feldspar porphyry, and some are of greywacke; the largest are 18 inches long. The section is conformable throughout.

In lot 19, on the V-VI range-line, Malartic township, the section from north to south is: 125 feet of medium- to coarse-grained, partly pillowed andesite; 100 feet of coarse, rhyolitic agglomerate grading upwards into 100 feet of finer, rhyolitic breccias and tuffs; 20 feet of drift followed by sheared, massive- to well-bedded greywacke. The boundary between the pyroclastics and the greywacke is not exposed, but its strike is delimited by several exposures on either side and must be very close to or the same as that of the beds of volcanic rocks.

In lot 21, range V, Malartic township, several outcrops of grey, siliceous agglomerate, similar to those in the last two sections above, were noted along the incompletely exposed contact zone.

In lots 23 and 24, range V, Malartic township, in the volcanic rocks 200 feet north of the contact two layers up to 20 feet wide of fine-grained, sedimentary tuff are interbedded in partly pillowed andesites. These rocks are succeeded southward by 20 to 25 feet of conglomerate, with angular to rounded pebbles of felsite and sedimentary rocks. The conglomerate along its south edge is bordered by and interbedded with greywacke and some amygdaloidal rhyolitic flows. The beds face southwest and all are definitely conformable. The volcanic rocks interbedded with the sediments rapidly decrease in amount southward across the strike. The flows are definitely lenticular, so that along the strike the succession of beds varies considerably. One thousand feet southeast a bed of greywacke and tuffaceous conglomerate 60 feet wide is bordered conformably on both sides by amygdaloidal dioritic and acidic lavas.

On the extreme east side of the area, at two places in the northeast corner of Fournière township, fine-grained, sedimentary rocks are separated by narrow strips of drift from outcrops of dioritic lavas or coarse-grained andesite. There is no evidence of any angular unconformity.

The various sections show that the Malartic period of volcanism closed with the production of acidic pyroclastics, which were scattered widely but discontinuously over the lava field. Beds of greywacke and conglomerate are interbedded with the volcanic strata, and in some places the sedimentary materials are mixed with the breccias and tuffs. The lenticular character of the beds within the contact zone, and the fact that in some places coarse conglomerate rests directly on massive greenstone, indicate the presence of irregularities on the surface of the lava field. Here and there local unconformities exist. However, the general lineal character of the contact demonstrates that the upper surface of the pile of volcanic rocks was nearly level.

KEWAGAMA GROUP

The Kewagama group is made up of clastic rocks that overlie the Malartic volcanic rocks and are overlain by the Blake River volcanic group. The group outcrops in two bands, on opposing limbs of a major syncline. The two bands continue westerly into Cadillac area where the senior author gave the name Kewagama sediments to the rocks of the northern band and Fournière sediments to those of the southern band,

because, though suspected, it was not then certain that the rocks of the two bands were correlative. Now that the structure is known, the rocks of both bands are placed in the Kewagama group.

On the north limb of the syncline rocks of the Kewagama group extend diagonally across the full length of the area. The group is thickened around some of the drag-folds, but normally on this limb it ranges from 1,000 to 3,000 feet thick. On the south limb a maximum width of over 6,000 feet of these vertically or steeply dipping sediments was examined during the present work, but only the northern 3,000 feet are known to face north. Three thousand feet is, therefore, the known minimum thickness of this part of the sedimentary group. The actual thickness may be much greater, for James and Mawdsley mapped continuous sediments southward to the northern edge of the great granite batholiths, a distance of 2 to 6 miles, but it is more than probable that in this region there are many repetitions of beds in isoclinal folds or drag-folds.

The Kewagama group is mostly greywacke, but includes some conglomerate. The northern band is fairly well exposed in a number of places, and nearly complete sections were obtained in three localities. The rocks of the southern band outcrop in numberless places, but all the exposures are small and continuous sections are lacking.

In the northern band, thin beds of conglomerate near the contact of the Malartic group have already been described. Quartzose to arkosic and argillaceous greywacke makes up the rest of the band. Argillaceous greywacke in beds 3 to 4 inches thick is common only in the lower 750 to 800 feet; this rock has an average grain of about 0·02 mm. and a well-developed cleavage parallel to the bedding. It weathers dull grey and is dark grey to black when fresh. A few tiny, sparkling flakes of biotite are usually visible on fresh surfaces. The chief minerals, in order of decreasing abundance, are white mica of sericitic habit, chlorite, albite, quartz, epidote, and biotite. At least three-fourths of the northern band, however, is metamorphosed, arkosic and quartzitic greywacke. Weathered surfaces are dull grey, rough with projecting quartz grains, and of notably uniform appearance over large areas. Bedding is characteristically poor or not discernible, but cleavage is moderately well developed. Thin ribbons of quartz a few inches long lie along some of the cleavage planes; on weathered surfaces these project $\frac{1}{8}$ inch or so in crinkled blades. Grains of quartz, to 2 mm. in diameter, white spots of feldspar, biotite, and, here and there, a few cubes of pyrite, can be recognized in most hand specimens. Thin sections show the feldspar to be entirely albite (An_{3-5}); epidote, chlorite, white mica, and magnetite are present in all, and grains of titanite, apatite, and zircon are common. Many of the quartz grains, though with recrystallized, sutured margins, are clearly clastic. Large grains of albite, with sieve texture and deeply sutured margins, are almost certainly recrystallized; some of the small grains in the matrix may be clastic. Though these sediments were derived for the most part from a volcanic region of widely diversified rock types, including large quantities of andesite, practically all the feldspar now present in the greywacke is albite.

The southern area of the group is made up entirely of greywacke. Conglomerate was not found in it, and James and Mawdsley discovered none in their mapping south to the granite. A few thin beds of tuffaceous origin, 2,500 feet west of Canadian Malartic No. 1 shaft, carrying angular fragments of sedimentary rocks up to 1 inch in diameter, are the coarsest varieties found in the present work. The greywacke is exposed in many places from Pandora mine east and southeastwards. Generally it stands in ridges above the greenstones that occupy the low-lying ground immediately to the north. Most of the ridges have been logged and burned, and are now covered with a heavy second growth of poplar, birch, and spruce. Exposures are small, discontinuous, and, except in a few places, covered with lichen or thin moss.

Beds of the northernmost 3,000 feet of this band, all that is certainly known to face northward, are fairly well exposed at and near Cartier Malartic ground, but the section examined in greatest detail is in a small cleared area on Canadian Malartic property (*See* Figure 2). These greywackes are moderately coarse, even-grained rocks, which weather grey to brown. Bedding is quite distinct except where obscured by schistosity. Beds of argillaceous greywacke 1 to 2 inches thick alternate with arkosic beds of similar thicknesses. Crossbedding and gradations in grain size within individual beds are sufficiently well developed in several places to show the direction in which the beds face.

The southern grewwackes are the most highly metamorphosed rocks in the area. Not only is schistosity much more pronounced than in the corresponding beds of the north limb of the syncline, but in addition growth of the constituent minerals has progressed much farther. Typically they are highly schistose, even-grained, finely banded rocks, dark brown to black where fresh, and weathered dark grey. They are composed of plagioclase, which, with few exceptions, is oligoclase-andesine (An_{28-32}), quartz, and biotite, in an aggregate of 1 to 2 mm. grains. Flakes of biotite up to 2 or 3 mm. in diameter are prominent on cleavage faces, and tiny cubes of pyrite are widely distributed. Apatite, zircon, and epidote are common constituents; small flakes of chlorite are distributed through many of the rocks and along some of the cross-fractures it replaces biotite. Garnet was discovered in one specimen collected on Don Martic ground, on the extreme southern side of the area. The greater metamorphism of these rocks, in comparison with those farther north, is probably attributable to their being nearer the southern granites.

RELATIONS OF THE KEWAGAMA GROUP TO THE BLAKE RIVER GROUP

The Kewagama group is overlain by the Blake River group of volcanic rocks. The contact on the southern limb of the syncline has been cut in diamond drill holes in several places, but all the rocks are severely sheared and metamorphosed, so that little can be learned from them regarding its character. It is exposed at the surface in only one place, on Pan-Canadian property. There, even-grained, biotitic greywacke is overlain by sheared greenstone. Bedding cannot be discerned in this locality, but elsewhere the

attitudes of beds in the two groups are strictly parallel. There is, therefore, structural conformity at least, though there may be some disconformity.

The contact in the northern limb of the syncline is exposed on the True Fissure, Thompson Malartic, and Malrobic properties, and in several places, each a few feet long, near the east side of the area. On True Fissure ground an exposure of fine-grained greywacke is separated by 30 feet of drift from a 6-foot outcrop of highly chloritic tuff or tuffaceous sediment, succeeded by 35 feet of foliated andesite. A short distance west, 20 feet of buff to white weathering, thin-bedded, hard, greenish grey, tuffaceous sediment passes gradationally upward into highly altered, laminated, fragmental greenstone. On the Thompson Malartic, Malrobic, and Panamint properties, typical, medium-grained, massive greywacke grades upwards into fine-grained, tuffaceous beds of siliceous material, most of which is highly carbonatized. These beds, 35 to 90 feet thick, grade without discernible break into basic greenstone schists overlain by massive or pillowed andesite. No sharp contact between the sediments and the volcanics exists. Narrow beds of tuff are interbedded with the flows for 400 to 800 feet above the greywacke.

On lots 46 and 47, range I, Malartic township, the conformable contact between sediments and lavas and tuffs is well exposed in half a dozen old trenches. On the west greywacke and green tuffs are interbedded in the contact zone, but farther east about 25 feet of grey, siliceous microporphyry, with albite phenocrysts, lies at the contact. This rock resembles that on the contact at the Malrobic and Thompson Malartic properties and is probably either a siliceous tuff or an altered rhyolitic flow. Some narrow beds of sediment lie in the greenstone to the south, and on lot 49 at least one layer of greenstone occurs in the sediments to the north of the main contact. Two and one-half miles to the northwest, in a trench on lot 33, range III, Malartic township, there is a gradation from greywacke through tuffs to lavas. It is concluded, therefore, that in the northern area the Kewagama and Blake River groups are conformable in the strictest sense of the word.

BLAKE RIVER GROUP

The Blake River group consists of volcanic rocks with a few intercalated sedimentary beds; it overlies the Kewagama group and is overlain by the Cadillac group. The name Blake River was given by the senior author to these rocks in the north limb of the syncline in Cadillac township, but their counterpart in the southern limb of the fold was termed the Cadillac belt. Blake River is applied to both bands in Malartic area, but the southern band may be distinguished by the name Cadillac belt. The beds of the group dip vertically or very steeply; normally, the assemblage is from 1,000 to 2,500 feet thick. The northern band thins to 700 feet or less at the east edge of the area. The southern band is thinnest at the west end where in places it is less than 200 feet thick, probably as a result of intense shearing.

Exposures of the Blake River rocks are few, small, and scattered. In the northern band there are only two reasonably complete sections, one on the True Fissure property and the other in lots 17 to 19, range V, Malartic

township. The rocks are petrographically indistinguishable from those of the Malartic group. Coarse- to fine-grained, massive or pillowed andesites and dacites make up most of the lower part, but in the upper part dacite predominates accompanied by some rhyolite and trachyte. Small amounts of tuff and agglomerate are interstratified with the flows. Crystalline, gabbroic to dioritic sheets, identical with phases of the diorite or "older gabbro" associated with the volcanic rocks of the Malartic group, occur at several places in the Blake River group, but more abundantly in the southern than in the northern band. These coarse-grained rocks, rich in amphibole, are confined to the volcanic rocks and nowhere intrude the overlying sedimentary rocks of the Cadillac group. As in the Malartic group, it is difficult to separate the dioritic intrusive from coarsely crystalline andesite flows.

Conglomerate and greywacke were found in only two places within the Blake River group. In lot 21, range IV, Malartic township, a bed of conglomerate 50 feet thick, with pebbles up to 3 inches in diameter of quartz-feldspar porphyry, felsite, greywacke, and greenstone, is underlain by coarse-grained andesite and overlain by coarsely crystalline diorite or gabbro (*See* Figure 3). This conglomerate bed may be a correlative of another exposed at the second locality, 1 mile northwest in lot 18, range V, but outcrops are too few to allow tracing through of the beds. The conglomerate and the associated greywacke into which it grades are intensely sheared, and the pebbles are squeezed into ellipsoids that lie with their greatest and intermediate axes in the planes of schistosity. Most of the pebbles are small, with an intermediate diameter of ½ inch or so. The strata are contorted, and, as the schistosity maintains a uniform strike throughout, the bedding is largely obscured or obliterated.

These sedimentary rocks, as shown by the bedding and sorting, are water laid. They are underlain by pillowed andesites and overlain by acidic breccias, tuffs, and pillowed flows. Their character and manner of occurrence show that the surface of the volcanics, in this locality at least, was covered with water, a feature that may account for the extensive development of pillows in the lavas that erupted just before and just after the brief period of sedimentation.

In Cadillac township the senior author was able to divide the Blake River volcanics into three parts: a lower, northern part, of andesite, making up half of the total thickness; a band of rhyolites; and an upper assemblage of tuffs and agglomerates. The rhyolites can be traced eastward in Malartic area to the True Fissure property. Similar rhyolites outcrop farther southeast, in lot 11, range V, Malartic township, at the same horizon, and presumably are continuous under the drift between the two places. Still farther east, in lot 18, range V, Malartic township, a thick series of andesites is overlain by a lenticular bed of conglomerate and greywacke, succeeded by acidic lavas that are covered by 600 feet of intermingled pillowed dacite, tuff, and breccia. Thus, the sequence is strikingly similar to that in Cadillac township. The bulk of the rocks exposed still farther southeast, in lots 18 to 26, ranges III and IV, Malartic township, are dacitic to andesitic lavas and fragmentals, but only a small fraction of the whole group is exposed. Farther southeast there are very few exposures of the north band of the Blake River group. There are

scattered outcrops of diorite, andesite, and mica-chlorite schist in lots 31 to 35, range II, Malartic township, and three small exposures of chlorite schist and sheared porphyritic andesite on the south shores of the lakes in ranges I and II.

Andesite, dacite, related tuff, and schist compose the outcrops in range I, Malartic township, at the east end of the area, but as the northern band of the Blake River group passes into Fournière township it becomes more difficult to follow. The volcanic rocks are intruded by small porphyry bodies and are very highly metamorphosed. A few exposures are readily recognized as andesite, amygdaloidal andesite, or tuff, but most of them are schist, amphibolite, or carbonatized phyllite. Biotite schist is fairly common, but not as abundant as chlorite schist. One or two exposures near the township line indicate that sediments and volcanics are interbedded in the lower part of the group. The southern contact, or what has been taken for it, is quite sharp in the one place where it is exposed; laminated chlorite schist abuts sharply against amphibolitized greywacke. At the extreme southeast end of the north band of the Blake River group the rocks are so largely altered to chlorite and mica that it is practically impossible to distinguish between volcanic rocks and sediments; the projection of the band to that point rests solely on the occurrence of a few small exposures of undoubted greenstone in the highly metamorphosed zone.

The southern band of the Blake River group is generally referred to as the Cadillac belt. All the mineral deposits of major importance that have as yet been developed lie in or near the belt. Therefore, its economic importance is great, but unfortunately outcrops along it are very few. In addition, the rocks that constitute it are in large part so highly sheared and altered that only a little can be learned as to their original character (*See* Plate I). The best exposures are on Pan-Canadian ground in Cadillac township (*See* Figure 4). A zone 100 to 200 feet wide at and above the lower (south) contact, where encountered in three places across the property, is intensely sheared. The rocks have been converted entirely or in part to soft, slickensided, chlorite schists similar to those of the "Cadillac Break" as known in western Cadillac township. North of the sheared zone, in which the mineral deposits of the Pan-Canadian No. 1 lie, there are less schistose, massive to pillowed andesites and fine-grained diorite. Above this again some greywacke and several narrow beds of siliceous tuff are intercalated with the lavas and other diorite bodies.

A body of diorite 250 feet wide, which may be a sill, occurs near the top of the group at the Cadillac-Malartic township line and can be seen at intervals for 2,400 feet along the strike. It appears to cut across the strike of the flows and there is other evidence along the east end of the south contact that the body is intrusive. A similar body occurs at about the same horizon one-half mile to the northwest and seems to pinch out not far west of the Pan-Canadian No. 1 shaft.

The rocks exposed in the large drag-fold southeast of Heva River are predominantly dense to dioritic andesites that become more schistose toward the east nose of the structure. They are intruded by irregular bodies of sheared albite porphyry.

The few exposures of the Blake River group at Maritime Cadillac and Lapa Cadillac mines are of andesite, tuff, diorite, and schist. At the

Maritime Cadillac mine volcanic and sedimentary rocks are definitely interbedded in the contact zone of the Cadillac group. Diamond driling and underground work on the properties has indicated very complicated structures, pronounced shear zones and faults, and a number of minor sodic intrusives within the Blake River group.

Southeast of Pan-Canadian ground there are very few outcrops of the Blake River group. At the Partanen Malartic property there are exposures at intervals along both contacts, and the width of the group is established at about 2,300 feet. On the north, diorite and andesite abut conformably against greywacke of the Cadillac group. The southern contact lies within a wide zone of shearing recently outlined by drilling and trenching for about one mile. The zone is intensely sheared across widths as great as 400 or 500 feet, with normal greywacke on the south, massive greenstone on the north, and bodies of diorite and feldspar porphyry within it. There is no evidence of angular discordance in the area, so far as the writers know, but the schistose character of the south contact zone prohibits a very clear understanding of the structural relations.

Pillowed, massive, and sheared andesites, with amphibolites and diorites, are exposed in a few places as far southeast as the Sladen Malartic property. The volcanic rocks are intruded by a body of granite porphyry on the Malartic-Fournière township line. Farther southeast the outcrops are even fewer and the rocks become more highly metamorphosed. On the East Malartic and Demara properties the lavas are so carbonized, serpentinized, or converted to chlorite and serpentine schists as to mask their original composition. A diorite intrusive is exposed on East Malartic group north of the highway. Drilling and underground work at this property has indicated intense shearing and alteration of the greenstone in the vicinity of Nos. 1 and 2 shafts, and at the No. 2 the volcanic rocks and sediments appear to be interbedded near the north contact of the Blake River group. Drilling along the south contact, at No. 3 shaft area, has indicated a wide zone of shearing along the contact, with the lavas converted to chlorite-carbonate schists and penetrated by bodies of diorite and porphyry.

There are a few exposures of andesite, diorite, amphibolite, serpentine, and schist across the northern part of the belt at Rand Malartic mine, and a pronounced shear zone about 50 feet wide has been proved along the north contact. This area contains many irregular intrusions of acidic porphyries. Recent drilling through deep overburden along the southern part of the south band is reported to have revealed conditions similar to those farther west at the East Malartic property. The Blake River group does not outcrop farther east, but much diamond drilling has been done on Malartic Goldfields ground and has established the width of the group there at about 2,300 feet. The usual assemblage of serpentinized, schistose, and dioritic lavas is indicated by the drilling. Porphyry intrusions occur all across the belt, but towards the south side, where most of the drilling has been done, are particularly abundant and excessively irregular. Diorite bodies also occur there.

RELATIONS OF THE BLAKE RIVER GROUP TO THE CADILLAC GROUP

The contact of the Blake River rocks with the sedimentary rocks of the overlying Cadillac group is exposed on the north limb of the syncline in only two places, in old trenches near the east side of Fournière township. The rocks there are sheared, amphibolitized, and mineralized with pyrite, quartz, and tourmaline, but the two groups appear to be conformable. Elsewhere along this limb the attitudes of the beds within the two groups are parallel, indicating structural conformity.

The contact with the Cadillac strata is best exposed on the south limb of the syncline at and near the Pan-Canadian mine (*See* Figure 4). Pillowed and massive andesite with interbedded greywacke is overlain with structural conformity by conglomerate and greywacke. At the west end of the exposures two beds of conglomerate, each 25 feet thick, are separated by 100 feet of greywacke; eastward within ½ mile the intervening greywacke pinches and the two conglomerate beds merge into a bed 100 feet thick, lying on greenstone. One mile to the east two thin beds of conglomerate lie just above the volcanic rocks, separated from them by 50 feet of greywacke. Pebbles in the conglomerate range in size up to 30 by 15 inches, though most of them are less than 6 inches in diameter. There are a few of felsite and syenite porphyry and many of greywacke, but, though the conglomerate rests directly on greenstone in many places, there is a complete lack of greenstone pebbles. Evidently the material of the conglomerate was not derived in situ, but was brought from a distance. Thus the presence of a conglomerate at the base of the Cadillac group is not evidence of an erosional unconformity at this place. On the other hand, the evidence of structural conformity between the two groups in other parts of the area, and the several indications of overlap of sedimentary and volcanic processes, lead to the conclusion that the Blake River and Cadillac groups are strictly conformable.

CADILLAC GROUP

The Cadillac group consists of clastic sedimentary rocks and overlies the Blake River group. It is the easterly continuation of the Cadillac sediments of Cadillac township, as described in Memoir 206. The strata occupy the centre of the regional syncline and outcrop across the area in a strip that ranges in width from ¾ mile to 2 miles. North of range III, Malartic township, there have been forest fires, and outcrops, though scattered, are fairly numerous. To the south, in unburned country, there are few outcrops and most of them are moss-covered and hidden in thick bush. Observations are correspondingly unsatisfactory, and available data on the structural relationships, particularly at the southeastern end of the area, leave much to be desired.

Because of incomplete exposures and complexities of structure an exact measure of the thickness of the group cannot be made. At the widest part of the syncline the sediments in each limb are approximately 5,000 feet thick. This thickness decreases westward to 3,500 feet and eastward to 1,600 feet, but the decrease is probably due to a gentle plunge of the fold

from either end toward the centre, rather than to thinning of the sediments as deposited. Five thousand feet can, therefore, be taken as the minimum thickness of the group. The top, and, consequently, the total original thickness, is unknown.

The Cadillac group is made up almost entirely of greywacke and conglomerate, but includes some green, tuffaceous and agglomeratic beds, layers of iron formation and magnetite, beds of quartzite, and chlorite, hornblende, and mica schist. The best exposures are on either side of the Malartic-Cadillac townships line in ranges IV and V.

The distribution of conglomerate and greywacke is shown on the accompanying maps. Conglomerate is proportionately most abundant in the eastern end of the area, where it was found at intervals across the area occupied by the group. In the west it occurs chiefly in the southern limb of the syncline. Conglomerate close to or resting directly on the underlying Blake River volcanic rocks was found northwest of Lapa Cadillac, at Pan-Canadian, and at Rand Malartic mines, but only at the Pan-Canadian are the contact exposures good. Individual conglomerate beds are lenticular and vary in thickness from a few inches to about 100 feet. However, there is every gradation from massive conglomerate with pebbles forming 50 per cent or more of the rock to greywacke with only a few pebbles scattered several feet apart. Assemblages of intercalated conglomerate and greywacke of this sort attain thicknesses of 500 to 1,000 feet and perhaps more.

Pebbles range in size up to 30 by 18 inches. By far the most common varieties are of felsite, feldspar or quartz-feldspar porphyry, and greywacke, but a few of quartz, quartzite, chert, and diorite can usually be found in a large exposure. Only a few pebbles of granite, possibly a dozen or so in all, and none of greenstone were found.

The greywacke is mostly well bedded, with argillaceous layers ½ inch to 6 inches thick alternating with arkosic beds of greater average thickness. In some large exposures, beds one-half inch or so thick can be followed for several tens of feet. Crossbedding is decidedly rare and gradations of grain size are not common. Schistosity is moderately well developed and in general is parallel to the bedding and has been drag-folded with it, but in places it cuts across both bedding and drag-folds.

The argillaceous greywacke is a fine-grained, cleavable rock, dark to light grey when fresh, and dull buff or blue-grey where weathered; scratched with a pick it feels soft and chalky. The rock is composed of grains of albite and quartz, mostly less than 0·1 mm. in diameter, biotite, chlorite, epidote, and white mica of sericitic habit, with scattered grains of zircon, apatite, titanite, tourmaline, and iron ores.

Coarse varieties of greywacke are less schistose than the argillaceous types. Fresh surfaces are dark grey or almost black; weathered surfaces are somewhat lighter and feel gritty under the point of a pick. The rock is composed of grains of albite and quartz 2 or 3 mm. in diameter, biotite, chlorite, epidote, white mica of sericitic habit, and scattered grains of apatite, zircon, titanite, tourmaline, and iron oxides. With variations in the amounts of albite and quartz the greywacke ranges from arkosic to quartzitic; true arkose is extremely rare.

All the mineral constituents of the greywackes have sutured borders and sieve textures; evidently they, with the possible exception of some clastic quartz grains, crystallized since the deposits were laid down. Many undeformed flakes of micaceous minerals are oriented at random across the planes of schistosity, showing that crystallization took place after schistosity developed.

An unusual greenish variety of greywacke outcrops in lots 1 to 5, range V, Malartic township, near the centre of the syncline. Diamond drilling on the Deane-Cadillac property has penetrated what is believed to be the westward continuation of the same beds, and small exposures of similar rocks occur on the Sladen Malartic claims in Cadillac township southeast of Lapa Cadillac mine. This variety of greywacke, both coarse and fine grained, is distinctly green and some phases closely resemble greenstone. The sedimentary origin is shown, however, by well-developed bedding, by the presence of clastic grains of quartz throughout, and in some beds by scattered pebbles. The green colour is due to an unusual abundance of chlorite and actinolite; some of the beds are composed almost exclusively of these minerals and have been termed amphibolite; others show complete gradations to normal greywacke, both along and across the strike. A plausible explanation to account for the local increase in basic material is to suppose that it fell as tuff, but the beds are so metamorphosed that any shards, if they ever existed, have long since been destroyed, and except in two places where coarse fragmental beds occur the diagnostic evidence of pyroclastic origin is lacking.

Quartzite and arkosic quartzite is restricted to a rather narrow zone in the Cadillac group. It begins as well-defined, grey to white weathering, gritty beds up to 50 feet wide in Cadillac township 1,500 feet west of Malartic township, and has been found at intervals southeastward as far as the old Grover Daly property in the southern part of lot 23, range III, Malartic township. Between these two points it outcrops in the northern parts of lots 3 to 5, range IV, and lot 15, range III, Malartic township. Similar beds are exposed in Fournière township just south of lot 45, range I, Malartic township, and on the Malartic highway 4,000 feet east of the east boundary of the property of East Malartic mines. These exposures lie approximately on strike with one another; the quartzitic beds may thus constitute one of the very few easily recognizable and continuous horizons within the Cadillac group.

Iron formation and beds rich in magnetite enter the area in the west, north of the Cadillac highway, and are moderately well exposed on the Rubec claims. The scattered outcrops and occasional strong local magnetic attractions in drift-covered areas within the northern half of the Cadillac group indicate that these ferruginous beds continue southeastward as far as the Little Heva River drag-fold, but true iron formation probably decreases in abundance in that direction. No iron formation or magnetite beds were observed southeast of lot 17, range IV, Malartic township. Even in Cadillac township only a few magnetic strata were found in the southern half of the area of the Cadillac group; the farthest south and east being near the old Lartic shaft. The varieties are similar to those found in Cadillac area, described in some detail by the senior author in Memoir 206, as follows:

"There are two main types. In one, beds of magnetite a fraction of an inch to several inches, and occasionally a few feet, in width, are intercalated with normal greywacke. Individual beds of magnetite tend to be lenticular and discontinuous, but zones of beds often persist for considerable distances. The magnetite grains in the beds are small, varying from dense, almost flinty material to granules and crystals about one-eighth inch across. Some narrow beds are very pure, but in many there is a large proportion of quartz and other impurities.

"The second variety is more strictly iron formation. In this case widths of a few feet to an exceptional 150 feet consist of a beautifully banded assemblage of magnetite, specularite, jasper, and greywacke. Greywacke is often entirely absent across widths of 10 feet or more. In many places there are small bands and veinlets of white quartz which is commonly cavernous and in some cases carries pyrite. In some places the intercalated and adjoining sediments are heavily chloritized and converted to hornblende. In these finely banded formations minor faults and folds are very noticeable and form a quite conspicuous feature of the strata. As a rule magnetite is much more abundant than specularite, but in a few places wide beds are largely specularite.

"The nature of the magnetite beds, varying from nearly pure beds to varieties in which there is merely a small proportion of magnetite grains disseminated in normal greywacke, strongly suggests that the iron oxide is of sedimentary origin. Probably, as Bancroft suggested many years ago, they represent old beds of black sand laid down with the greywacke. The typical iron formation, however, with its purplish to brick-red layers of jasper and some of dense, grey silica more resembles a sedimentary formation in which at least some of the silica and iron formed as chemical precipitate in the sediments. Metamorphism has produced complete recrystallization so that what is now magnetite, or specularite, may have been some other iron compound originally."

The conclusion that the iron-bearing beds are probably of sedimentary origin is supported by some observations made during the present work. Some well-exposed beds were traced for over 100 feet and one for over 400 feet along the strike; all are perfectly bedded throughout. Beds rich in magnetite grade by a decrease in the relative number of magnetite grains into normal greywacke, and the gradation takes place both along and perpendicular to the strike. The quartz grains in the iron-rich beds differ in no way from the clastic grains of typical greywacke. Altogether there seems to be little reason to doubt the sedimentary origin.

Why such exceptional amounts of iron should be concentrated within a fairly narrow zone, and should appear nowhere else, still remains to be explained. It may be noted, however, that the iron formation in this district is commonly associated with the greenish varieties of greywacke described above. If these greenish beds originated as tuffs the concentrations of iron may have been associated with the same volcanic activity.

A number of puzzling exposures of schist appear at the east end of the area of the Cadillac group eastward from the east boundary of East Malartic mines. The outcrops, though fairly abundant, are in bushy and timbered terrain, so that clean exposures are limited. The rocks are hornblende, chlorite, and mica schist, but indubitably include much grey-

wacke and conglomerate. The alteration is in places so intense that the writers could not satisfy themselves that there are not intercalations of andesite and volcanic breccia with the sediments in one or two localities. There are, also, some small exposures of augite porphyry that probably represent basic dykes. The marked schistosity and some pronounced scarps strike almost due east, facts that may be indicative of major faults. Possibly in this eastern part of the syncline the structure is much more complicated than assumed, with, perhaps, complicated folding or faulting that causes some apparent intermingling of the Cadillac sedimentary rocks with volcanic rocks of the upper part of the Blake River group. The high degree of metamorphism and the exposures of basic porphyry are also suggestive of intrusive rocks below the surface.

As shown by the rounding and sorting of the pebbles, and by the general clean-cut separation of fine-grained, argillaceous, from coarser, arenaceous, greywacke in thin, extensive beds, the Cadillac sedimentary rocks are water-laid deposits. Crossbedding, even in coarse-grained greywackes associated with conglomerate beds, is very scarce. Some crossbedding may have been destroyed as the schistosity developed, but although all the beds are schistose such crossbedding as does occur is little distorted. No recognizable mud-cracks, ripple-marks, or other features indicative of intermittent exposure of the unconsolidated sediments to the air were observed. The conclusion is that the greywackes were laid down in a body of standing water. The conglomerates are near-shore deposits, too well bedded and sorted to be subaerial in origin. These lenticular beds, surrounded by, interbedded with, and grading into greywackes, show that there were local depositional currents of some strength. The pebbles may have been derived in part by wave action along the shore or, more probably, were delivered by rapidly flowing streams debouching into the depositional basin.

INTRUSIVES

GENERAL DESCRIPTION

Malartic area lies midway between and 2 to 6 miles from the Preissac-Lacorne batholiths on the north and a southern area of granite that extends far to the east and the west. The largest intrusive body within the area is a granodiorite sill 5 miles long, on the south shore of Malartic Lake. More acidic types include at least six, small, stock-like bodies of granitic rocks and numberless dykes of several varieties, including feldspar and quartz-feldspar porphyries, albitite and quartz-albitite, and albite porphyry. In addition there are dykes of quartz diorite, diorite, serpentine, basalt (?), biotite lamprophyre, amphibolite, and diabase.

The relative ages of the intrusive bodies are not fully known. Quartz diorite and diorite are cut by dykes of feldspar porphyry. Serpentine is associated only with the Malartic volcanic rocks, possibly an indication of very early age, and in one place a serpentine dyke is intruded by a dyke of feldspar porphyry. The granodiorite porphyry sill is cut by dykes of quartz-albite porphyry, feldspar porphyry, biotite lamprophyre, and basalt. The two varieties of porphyry are older than lamprophyre. The

relative ages of the other intrusives are not fully known, but it seems probable that most of the acidic dykes and related lamprophyres belong to one post-Cadillac period of intrusion. The younger diabase dykes commonly supposed to be younger than the Cobalt series are part of the remarkable system of these intrusives that extends across northwestern Quebec.

The distribution of the acidic intrusives within the Malartic area needs some comment. There are remarkably few dykes and no large intrusive bodies within the rocks of the Cadillac group. At Rubec, Hayes Cadillac, Sladen Malartic (property in Cadillac township), and Deane Cadillac properties there are single dykes of porcelaneous to porphyritic albitite. The four occurrences may possibly be part of a single intrusive. A few small dykes of aplite are exposed on Dunlop Consolidated ground south of the Cadillac township centre line, and a very small dyke is known in the sedimentary rocks on the Dempsey Cadillac property. In striking contrast with this the Malartic volcanic rocks and the Kewagama and Blake River groups on both sides of the syncline, besides including all the larger stocks, are cut by hundreds of acidic dykes. The remarkable scarcity of intrusives in the rocks of the Cadillac group can hardly indicate that most of the intrusives are older than the Cadillac group, for all the acidic intrusives appear to be closely related, and many are intruded into shear zones known to be younger than the Cadillac group. Possibly the synclinal core of Cadillac sediments was protected from intrusion by the sheaths of older volcanic and sedimentary rocks beneath it. The bedding planes, schistosity planes, and bedded shear zones of thin outer sheaths would tend to deflect intrusives arising from depth. The remarkable abundance of dykes and small bodies of acidic intrusives along the highly sheared rocks of the southern band of the Blake River volcanic rocks, and the entire lack of these intrusives in the conformably overlying sediments of the Cadillac group, point to such protective structural control.

SERPENTINE DYKES

Serpentine dykes are found only in the Malartic volcanic rocks, 5,000 feet or so below the top of the group, in a zone some 4,000 feet wide, extending from lot 10, range VIII, Malartic township, to lot 43, range IV, a distance of about 14 miles. The dykes are sill-like in that they lie parallel to the enclosing strata. The largest, in range X, is 230 feet wide, but several of the others are more than 150 feet wide.

The rock is easily distinguished from the volcanic rocks that it intrudes. In contrast with their dark surfaces, it weathers a distinctive brown, and is criss-crossed by innumerable reticulating veinlets of bluish weathering carbonate and a few of brittle asbestiform amphibole. The weathered rock is soft and feels greasy when scratched; broken open it is massive, harder, greenish grey, and finely granular. It is composed entirely of finely divided chlorite (serpentine), actinolitic amphibole, and powdery, black iron oxides. None of the original constituents remains, but some mesh-work patterns outlined by iron-oxide grains resemble those formed by secondary alteration of olivine. The rock may have been a peridotite, or a low-aluminium pyroxenite.

Contacts with volcanic rocks, where exposed, are sharp, and the country rock in most places has been little affected by the intrusion. However, in lot 18, on the sixth range line, Malartic township, two dykes of serpentine 180 and 50 to 100 feet wide, respectively, are separated by 30 to 70 feet of pillow lava that has been bleached and highly carbonatized. The alteration is so intense that in many places only faint outlines of the pillows can be discovered. Again, in lot 18, 1,800 feet north of the sixth range line, sheared greenstones on the north side of a 60-foot serpentine dyke have been severely carbonatized. A pit, 10 feet deep and partly waterfilled when visited, has been dug on the contact. Along the contact so exposed some amphibole with brittle fibres up to 2 inches long has been deposited with tourmaline in slickensided, chlorite-sericite schist. Later veins of coarsely crystalline white carbonate cut across the amphibole-tourmaline aggregate.

Several outcrops of serpentine on the East Malartic property have been tentatively classified as serpentinized lava. Details about them are given in the description of that property.

DIORITE AND QUARTZ DIORITE

One of the most difficult problems in mapping is that of distinguishing between intrusive diorite and dioritic phases of andesite flows. Many flows, with pillowed or brecciated portions, grade into medium to coarsely crystalline, massive diorite. Similar diorite in other places is intrusive. Unfortunately, and largely because of insufficient outcrop, in many places criteria for distinguishing flows from intrusives cannot be obtained. A number of bodies of diorite are represented on the accompanying map; they are considered intrusive, but in no case is the evidence conclusive. A good many other bodies that may be intrusive are not distinguished from the volcanic rocks of the Blake River and Malartic groups. This is particularly true in the southeastern part of the area, where it was impossible to represent properly a large number of small bodies of diorite, of very irregular outline, that have been penetrated by drill holes in the schists of the Cadillac belt.

One body of quartz diorite represented on the map is a sill of the type frequently classified as "older gabbro." Approximately 400 feet thick, it is intermittently exposed from the north end of lot 17, range VI, Malartic township, to lot 38, range IV; small exposures of similar quartz diorite at about the same stratigraphic horizon occur in lots 11 and 12, range VII, and in lot 6, range VIII, Malartic township, and may be parts of the same sill. Dykes of feldspar porphyry cut it. The quartz diorite is typically a coarse-grained rock, composed of quartz, epidote, albite, and amphibole, with accessary apatite and up to 6 per cent of magnetite. All the minerals, with the possible exception of some quartz, are of secondary origin. The amphibole has a marked sieve texture with inclusions of quartz, albite, and epidote. The albite crystals, commonly showing some crystal form, are charged with epidote granules, inclusions of amphibole, and quartz. Even the magnetite grains are full of inclusions of the other minerals. In short, the texture, with mutual inclusions of each mineral in every other, is typically metamorphic.

A feature of this quartz diorite sill is the variability of grain size, both across and along the strike. This characteristic is perfectly illustrated in lot 17, range VI, Malartic township, where the sill is exposed from contact to

contact. To within 3 inches of the northern or lower contact the rock is coarse grained with amphibole crystals up to ½ inch long and quartz and feldspar ¼ inch in greatest diameter. Towards the southern or upper contact the grain becomes progressively finer to a minimum of $\frac{1}{10}$ to $\frac{1}{16}$ inch near the top edge. In marked contrast with this, the grain size along the top in other places, for example in lots 17 and 19, range VI, Malartic township, is comparable with that near the bottom. In some places the rock is very coarsely crystalline, with crystals of amphibole 2 to 3 inches long set in a base of coarse-grained feldspar and quartz.

The other bodies of diorite represented on the map are similar, but smaller and finer grained.

At the East Malartic mine and farther southeast, irregular sheet-like bodies of an extraordinary rock also termed diorite have been found in the Blake River schists along the Cadillac belt. The rock is described in some detail in the account of the East Malartic property. It consists entirely of secondary minerals, albite is the chief or only feldspar, and the texture is typically metamorphic. At the No. 2 shaft the bodies are lenticular and discontinuous, lack clear-cut intrusive relations, and resemble bodies formed by metasomatic replacement of schist rather than intrusions.

ACIDIC INTRUSIVES

A rigorous classification of the many acid intrusives of the district is difficult if not impossible. Most of the masses are quite small, and all have been silicified, albitized, and carbonatized; in addition, many have been subjected to regional metamorphism. The original compositions, consequently, can at best be determined only approximately.

The names applied to the different intrusives include granodiorite porphyry, quartz-albite porphyry, albite porphyry, albite granite, porphyritic albite granite, quartz syenite porphyry, schistose albite porphyry, albitite, and quartz albitite. The granodiorite porphyry forms a body about 5 miles long and 3,000 feet in greatest exposed width that runs northwest along the south shore of Malartic Lake. The other bodies of acidic intrusives are all small, the largest being a mass about 3,000 feet long and 1,300 feet wide.

All the varieties of acidic intrusives cut the serpentine dykes and bodies of diorite, wherever they have been found in contact, and are cut by the lamprophyre dykes and quartz gabbro dykes yet to be described. These relations indicate that they were intruded toward the close of the Archæan era.

As the acidic intrusives seem closely related to the gold deposits they have been carefully studied under the microscope, and chemical analyses of some have been obtained. All the bodies are composed of quartz and albite, with minor amounts of other minerals; a few show evidence that the albite was derived from a more calcic feldspar. The petrographic descriptions of so many closely similar rocks make monotonous reading, but nevertheless are presented on the following pages where they may be consulted by operators wishing to know the precise nature of the acid intrusives appearing on their properties, or by readers particularly interested in petrographic detail.

GRANODIORITE PORPHYRY SILL AND ASSOCIATED DYKES

A body of granodiorite porphyry, probably a sill, is intermittently exposed on the points and islands along the south shore of Malartic Lake from lot 20, rang VII, to lot 29, range V, a length of about 5 miles. The sill is approximately 1,500 feet thick at the western end; elsewhere the southern contact is indefinite and the northern contact is unknown.

Glaciated surfaces of the rock are grey-green, with phenocrysts of opalescent quartz 1 or 2 mm. in diameter and a few of feldspar up to 2 mm. long in a dark, waxy green, aphanitic groundmass. The feldspar phenocrysts are zoned, and range in composition from oligoclase (An_{15}) to almost pure albite. In the least altered specimens the feldspar phenocrysts are flecked with flakes of white mica and many are changed to aggregates of albite, white mica, and granular epidote. The quartz phenocrysts are round or elongated and some are deeply embayed. Other constituents include dark green biotite, abundant epidote in grains 0·1 to 0·2 mm. in diameter, minor amounts of chlorite, and accessory titanite and pyrite. Orthoclase was doubtfully identified in only one section, and is certainly a very minor constituent.

Phases in which the phenocrysts are larger and more abundant, with crystals of feldspar 5 mm. to 1 cm. long, outcrop on the prominent point in lot 38, range V, Malartic township, and in one or two places near the western end of the sill.

The whole sill has been sheared and brecciated (*See* Plate II A). Shear planes are vertical and strike consistently 30 degrees south of east, parallel to the strike of the sill; breccia is widespread, but is best developed on the point mentioned above. The fragments have ellipsoidal forms, range in size up to 3 feet long, and are surrounded by thin layers of material in which everything but a few fragments of quartz have been crushed to grains 0·01 mm. or so in diameter. Associated with this breccia are narrow zones, none over 10 feet wide, in which the fragments have been converted by intense shearing into mylonite identical with the crushed material that encloses the fragments in the normal breccia. Good examples of such zones are exposed on the small island in lot 35, range VI, Malartic township.

The granodiorite porphyry is cut by many dykes of quartz-albite porphyry, biotite lamprophyre, and a basic rock, probably basalt. The quartz-albite porphyry is older than the biotite lamprophyre, as indicated by intersections on the large island in range VI, and on the point east of the Mining Enterprise camp-site. All the dykes are massive and although many follow planes of schistosity in the granodiorite porphyry, almost as many cut across at random angles. They were, therefore, emplaced after schistosity developed.

The quartz-albite porphyry is light coloured and has a blocky fracture. Phenocrysts of plagioclase feldspar up to 2 mm. long are found, but are rare. The main constituents, in decreasing order of abundance, are zoned plagioclase feldspar, sericitic mica, carbonate, and chlorite. Accessory apatite and a few granules of epidote complete the suite. The plagioclase feldspar phenocrysts range from about An_{10} in the centres to An_3 on the rims, thus falling entirely within the limits of albite. The feldspar in the groundmass is in small grains 0·1 mm. or less in diameter and is almost pure albite (An_{1-3}). The percentage of dark minerals, though variable, is less

than 10 per cent in many specimens. Alteration of biotite to chlorite, and development of sericitic mica, epidote, and, particularly, carbonate indicate hydrothermal action.

The biotite lamprophyre exhibits sparkling plates of brown biotite up to 5 mm. in diameter, liberally distributed in a dark green or almost black, fine-grained groundmass. The dykes have narrow chilled borders 3 inches wide or less. In these the groundmass is very fine and the biotite phenocrysts are somewhat smaller, 2 to 3 mm. in diameter. Thin sections reveal the presence of another generation of biotite in the groundmass. Albite-oligoclase (An_{10}) and quartz are moulded against some of the biotite plates. Carbonate is abundant in irregular grains and patches; it encloses flakes of biotite and appears to replace both plagioclase and quartz. Large crystals and grains of epidote are common, and apatite, titanite, black iron oxides, and pyrite are accessory. The country rock adjacent to the lamprophyre dykes appears, in general, to be little altererd, but on a tiny island in the north half of lot 36, range V, Malartic township, basalt intruded by biotite lamprophyre is changed to a mass of soft, flaky, bright green chlorite in an irregular strip 2 to 3 feet wide bordering the dyke. The dyke itself carries an unusual number of pyrite crystals.

Many fine-grained, massive, basic dykes, mostly 4 feet or less wide, cut the granodiorite porphyry. Age relations to the quartz-albite porphyry or to the lamprophyre were not established. The rock is now a confused mass of secondary minerals; originally it probably was basaltic in composition.

Some sulphides, chiefly pyrite with which gold is reported, are associated with the granodiorite porphyry. An exposure of mottled rock in lot 19, range VII, Malartic township, consists of dense, milky grey, sericitized granodiorite porphyry with lenticular inclusions of dark green chlorite schist, all sparingly mineralized with pyrite and said to carry some gold. Similar material is exposed on the lake shore on the northwest side of the point in lot 20, range VII. In lot 47, range V, on the nortwest side of the point, there is an outcrop of milky white, schistose, sericitized granodiorite porphyry identical with that farther west, but without the inclusions of chlorite schist. In this rock the few remaining albite phenocrysts are shattered, sericitized, and replaced in part by carbonate. Grains of clinozoisite and epidote are abundant, and there are a few tiny rods of tourmaline. This altered granodiorite is cut by a 3-foot dyke of feldspar porphyry with euhedral phenocrysts of white plagioclase in a grey groundmass of medium grain. Silicified, sericitized granodiorite porphyry is exposed 650 feet southeast along the strike of the shearing, south 30 degrees east. The altered porphyry may form a continuous zone between and beyond the two exposures.

Mineral deposits at the old Ledoux property, now Malartic Lakeshore, the north showing on Valco ground, and that at the Mining Enterprise camp-site may be associated genetically with the granodiorite porphyry.

ALBITE PORPHYRY

In ranges V and VI, lots 13 to 23, Malartic township, the Malartic and Kewagama groups are intruded by a swarm of dykes of albite porphyry. Over most of this area a small dyke or two is exposed in almost every out-

crop, but the swarm attains remarkable development in a strip 400 to 500 feet wide just north of the volcanic-sedimentary contact and again in a 300-foot strip across the fifth range line in lots 14 and 15. Similar dykes form a swarm in the outcrops in lot 8, range VII, Malartic township, and again around Thompson Malartic. In several places the dykes, which for the most part parallel the bedding of the host rocks, make up at least 25 per cent of the area of rock exposed. Most of the dykes are 4 to 10 feet wide, a few are 10 to 30 feet wide, and one crossing the fifth range line in lots 14 and 15 is 100 feet wide. The distribution of these dykes leads one to suspect that the few small outcrops of granite in the middle of lot 10, range VI, Malartic township, may be parts of an intrusion of some size, hidden in the drift-covered area in lots 5 to 15, ranges VI and VII.

The albite porphyry weathers pinkish or light grey and is somewhat darker where freshly broken. Feldspar phenocrysts up to 5 mm. long, with a few grains of quartz here and there, are seen in a groundmass that ranges from aphanitic in narrow dykes to medium grained in the widest. The 100-foot dyke is a massive, completely crystalline rock with euhedral crystals of zoned oligoclase-albite (An_{20}-An_6) 55 per cent, quartz 20 per cent, microcline 15 per cent, with muscovite, accessory apatite, and secondary epidote and chlorite making up the remaining 10 per cent. Deformation has crushed the edges of some of the crystals and developed mortar structure. The mineral composition of the smaller dykes is similar. Biotite is present in many instead of muscovite; titanite and allanite (?) are accessory in a few. The rocks are oligoclase-albite, albite, or quartz-albite porphyries.

Many of the dykes are crossed at right angles by quartz veins that do not extend into the wall-rock on either side. The veins commonly occur more or less regularly at intervals of a few feet, suggesting that they fill tension cracks that opened as the dyke solidified and shrank. The most spectacular display of these veins appears in the east end of the 100-foot dyke (*See* Plate II B). Within a length of 250 feet there are literally hundreds of veins, ranging in size from mere threads a few inches long up to lenses 3 feet thick and 20 feet long. Two of the larger veins are exposed in a pit on top of the hill formed by the dyke. The quartz is milky to vitreous, and the wall-rock is impregnated by considerable pyrite and tourmaline. No information as to possible gold content was obtained.

A few small dykes of biotite lamprophyre are associated with, and are younger than, the albite porphyry dykes. The 100-foot dyke is crossed diagonally by a 10-foot dyke of lamprophyre, and it in turn by veinlets of pink feldspar and quartz. The lamprophyre is petographically identical with the lamprophyres associated with the granodiorite porphyry.

ALBITE GRANITE

Within the Kewagama group, in range II, lots 1 to 15, Malartic township, and in the lower part of the overlying Blake River group, there are a large number of narrow dykes and small plugs of albite granite. Several of these albite granite dykes, as well as others of feldspar porphyry, were encountered in diamond drill holes in lot 13, range II, on a property now being developed by Partanen Malartic Gold Mines, Limited. One of the least altered bodies was cut in drill hole A. The rock is light grey and completely crystalline; the texture is hypidiomorphic granular. The rock is composed of euhedral to subhedral crystals of albite (An_2), quartz, and

biotite, with accessory apatite and titanite, and some secondary chlorite, carbonate, and a few grains of pyrite. The albite crystals, somewhat turbid and flecked with sericitic mica, are beautifully twinned, with the albite twins as seen on (100) showing a distinct tendency to spindle forms; chess-board twinning is common. Quartz, with strong undulatory extinction, and much cracked, is interstitial to plagioclase feldspar. Biotite flakes tend to a nested arrangement, with nests in part interstitial to, and in part enclosed in, plagioclase feldspar crystals.

The chemical analysis of this rock, by R. J. C. Fabry, is given below:

SiO_2	71·36
Al_2O_3	15·52
Fe_2O_3	0·70
FeO	1·19
CaO	1·31
MgO	1·08
Na_2O	6·20
K_2O	0·71
H_2O+	0·51
H_2O-	0·04
TiO_2	0·31
P_2O_5	0·22
MnO	nil
CO_2	0·66
S	0·17
Fe	0·15
Total	100·13

I	
Quartz	30·54
Albite (An_2)	53·51
Biotite and chlorite	12·18
Apatite	0·34
Titanite	0·20
Ilmenite	0·46
Calcite	1·50
Pyrite	0·32
Magnetite	0·93
	99·98

II	
Quartz	29·46
Albite oligoclase	58·20
Mica	10·21
Apatite	0·34
Titanite	0·20
Ilmenite	0·46
Magnetite	0·93
	99·80

As shown, two mineral compositions have been computed. The first is patterned after the present mineral composition of the rock. After enough lime was allocated for apatite, titanite, and calcite, there was exactly enough left to form albite of the composition $Ab_{98}An_2$, thus checking very satisfactorily with the composition determined by microscopic diagnosis. In computing the second mineral composition the carbon dioxide and the sulphur were disregarded. The lime formerly allocated to calcite thus became available for anorthite, and the plagioclase feldspar can be computed as albite-oligoclase ($Ab_{91}An_9$). According to the first composition the rock is mildly carbonatized albite granite; according to the second, an albite-oligoclase quartz diorite.

Alteration of the albite granite consists chiefly of silicification and sericitization; it has taken place for the most part along narrow zones, but one zone 15 feet wide was cut in hole A. In the first stage of the process biotite and chlorite disappear, and the rock becomes mottled pinkish or yellowish white. A few feldspar phenocrysts can be discerned in a groundmass composed largely of fine-grained quartz and sericite, with a few disseminated grains of pyrite. The groundmass, in the final stages, contains much more fine-grained quartz and is cut by anastomosing veinlets of white or vitreous quartz. The feldpsar phenocrysts are almost entirely replaced by mats of sericitic mica, pyrite may be somewhat more abundant, and a little carbonate developed. In hand specimen the altered granite resembles a grey or brownish grey chert cut by veinlets of milky to glassy quartz.

Other dykes and a large body of albite granite at and southeast of the old Cartier Malartic property closely resemble the albite granite described above, with, however, the addition of a small amount of microcline. Here again there is evidence that all the albite is not original, for it has appar-

ently attacked the microcline and replaced it in part. The replacement in these need only have been slightly more thorough and all the potash feldspar would have been obliterated without leaving a trace. As Güssow has shown in a recent paper, this process may be widespread and thoroughgoing, completely changing the character of the original rock and yet leaving a rock of deceptively "fresh" appearance in its wake[1].

Quartz veins of two ages are associated with a dyke of albite granite exposed near the middle of lot 9, range II, Malartic township, just east of the road. The dyke forms all of an outcrop about 75 feet long by 45 feet wide, with the exception of a few square feet in one corner where the contact with greywacke is exposed. The rock is porphyritic with euhedral phenocrysts of plagioclase feldspar 2 or 3 mm. long in a dark grey, fine-grained groundmass. The older set of veins, of milky to vitreous quartz, range from a fraction of an inch to 18 inches thick, and cross the dyke from side to side like the rungs of a ladder. They carry considerable tourmaline and some pyrite. Cutting directly across them is a biotite lamprophyre dyke 2 feet thick, and this dyke is cut in turn by tourmaline-free veins of bluish quartz, one 2 feet thick and two others each 6 inches thick.

On ground held by Valco Mines, Limited, in range I, not far south of Malartic Lake, a body of albite granite outcrops over an area of 1,300 by 300 feet. Its full limits are not known. The rock is brown to grey and holocrystalline, with feldspar crystals to about 3 mm. diameter. It intrudes volcanic rocks of the Malartic group and is in many places extensively veined and replaced by white quartz. Bordered on the south by a marked shear zone, it is itself in part sheared and sericitized. Samples for analysis were taken from near an old shaft, and are reasonably fresh and very uniform in appearance. The microscope reveals quartz, albite (An_5), and microline as the principal constituents. Some of the quartz shows undulatory extinction, the albite is considerably sericitized, and the microcline is relatively clear. Accessories are sericitic mica, greenish brown biotite, apatite, carbonate, and pyrite.

The analysis, by R. J. C. Fabry, is as follows:

SiO_2	69·93
Al_2O_3	15·47
Fe_2O_3	1·86
FeO	0·93
CaO	2·62
MgO	0·55
Na_2O	4·52
K_2O	2·72
H_2O+	0·34
H_2O-	0·09
TiO_2	0·31
P_2O_5	0·31
MnO	Trace
CO_2	1·05
S	0·26
	100·96
Less oxygen for sulphur	0·10
Total	100·86

[1] Güssow, W. C.: Petrogeny of the Major Acid Intrusives of the Rouyn-Bell River Area of Northwestern Quebec; Trans. Roy. Soc., Canada, sec. IV, 1937, pp. 129-161, especially 141.

Recalculated to conform with the microscopic determinations, the following is the mineral composition:

Quartz	32·2
Albite (An_3)	39·8
Microcline	5·6
Mica	16·0
Magnetite	1·2
Leucoxene	0·6
Pyrite	0·5
Calcite	3·4
Apatite	0·7
	100.0

The recasting is unsatisfactory as it produces too little microcline and too much mica to agree closely with the microscopic examination of the rock. It may be that more of the potash should be cast in microcline, but no very satisfactory result is obtained in this way. The difficulty lies, of course, in the fact that the exact composition of the mica and carbonate is not known, and quite different results can be obtained by using different assumptions.

A body of granite at least 1,200 feet across is partly exposed in range IX, just east of Cadillac township. Dykes of similar rock cut the Malartic volcanic rocks to the north and south. The granite has an average grain of about 3 mm. or less and is pale grey to pink. It is much fractured and veined by white quartz. Albite (An_7) forms about 60 per cent of the rock, microcline about 15 per cent, and quartz with undulose extinction about 20 per cent. The accessories are biotite, epidote, titanite, sericitic mica, and apatite. It is probably best classified as albite granite.

PORPHYRITIC ALBITE GRANITE

Three bodies of porphyritic albite granite are known in the area, one on the highway at the Malartic-Fournière township line and two in range IV, east of the highway.

The body on the highway is poorly exposed, but at the surface measures at least 2,000 feet by 1,100 feet. It is a grey rock with phenocrysts of feldspar up to one inch across in a granular groundmass. Quartz is present as smaller phenocrysts and in the groundmass. The large phenocrysts are albite (An_{3-5}). They contain poikilitic crystals of albite of the same composition up to 2·5 mm. across. Anhedral grains of albite, 0·2 mm. across, are abundant in the groundmass. There are a few crystals of microcline, of intermediate size. Quartz forms about 80 per cent of the groundmass. All the feldspar is charged with inclusions of the accessory minerals, dark green, partly chloritized biotite, apatite, sericitic mica, and iron oxide.

A possibly related dyke of grey quartz-feldspar porphyry is exposed 2,800 feet north of the Sladen Malartic shaft. Albite (An_4) and quartz phenocrysts about 2 mm. across are set in a groundmass of 0·025 mm. grain. Very minor accessories are biotite, sericite, apatite, rutile, pyrite, and carbonate. Worthy of note, as being unusual in this part of the area, are a few prisms of tourmaline.

Quartz phenocrysts are found in a body of porphyry at East Malartic mine. It might be inferred that the body is related, genetically, to the porphyritic granite, but it seems more probable that it is merely a quartzose variety of the quartz syenite porphyry body at the No. 1 shaft, for some phases of the two rocks are identical in appearance.

Two bodies of even-grained to porphyritic albite granite occur in lots 31 to 35, range IV, Malartic township, on ground that is being developed by Celta Mining and Development Company, Limited. The intrusives are cut by pegmatitic quartz veins that in places contain molybdenite and columbite.[1]

QUARTZ SYENITE PORPHYRY AND ALBITE GRANITE

From the Cartier Malartic claims to the east end of the area in Fournière township the Kewagama group and the schistose Blake River volcanic rocks of the Cadillac belt are intruded by many dykes and irregular bodies that in all previous reports on the area have been classified as quartz syenite porphyry. These intrusives have been studied in greatest detail at Canadian Malartic, Sladen Malartic, and East Malartic mines. They vary considerably in composition, texture, and degree of metamorphism. The major bodies are not always porphyritic. They and the dykes vary from feldspar porphyry to even-grained quartz syenite or granite. The quartz content is very variable; albite is the predominant feldspar, but potash feldspars are present in varying amount and a few thin sections contain considerable oligoclase. Colours range from shades of grey to brown and brick-red. Dark grey is probably the normal original colour; pale greys and red tints are largely restricted to hydrothermally altered bodies. Some of the dykes, however, apparently have an original red tint.

Further details of the petrography of the different bodies are to be found under the descriptions of properties in this part of the area. J. J. O'Neill[2] has described the intrusives at Canadian Malartic and Sladen Malartic mines in some detail. He distinguishes between the major bodies of quartz syenite porphyry and the smaller dykes of quartz-feldspar porphyry that are particularly evident along the north ore zone at Canadian Malartic, and although there are textural and compositional differences, as there are within the major bodies and between different dykes, it seems to the writers that all the intrusives are closely related. O'Neill has also suggested this possibility. This conclusion seems justified by the fact that dykes in the upper three levels of Canadian Malartic mine widen below in the fourth, fifth, and sixth levels to form a large, irregular body of quartz syenite porphyry. Some idea of the variations within this body is given by the following petrographic studies. A sample of grey porphyry from the sixth level station at No. 1 shaft is composed of about 50 per cent zoned obligoclase phenocrysts ranging from calcic oligoclase cores to almost pure albite rims, and some 10 per cent of microcline in part replaced by sodic plagioclase. There is about 15 per cent of quartz, and accessory titanite, iron oxide, biotite, epidote, apatite, carbonate,

[1] Th. Koulomzine, personal communication.

[2] "The Canadian Malartic Gold Mine, Abitibi County"; Que. Bureau of Mines, 1934, pt. B, pp. 68-69.

and anhydrite. The rock has been hydrothermally altered. A specimen from the same body on the fifth level consists of about 60 per cent albite (An_4) as phenocrysts up to 5 mm. across, a little orthoclase and microcline, about 20 per cent quartz, and minor amounts of pyrite, carbonate, sericite, biotite, and apatite. Some very clear albite has been introduced along with quartz. A red phase of the porphyry from the sixth level is over 65 per cent albite (An_3) and contains very little quartz. A few orthoclase phenocrysts are almost completely replaced by albite. Microcline is present in the groundmass as well as the usual accessories. The albitization and red colour are probably related phenomena; finely disseminated hematite dust causes the colour. The specimen was collected alongside the pegmatitic quartz ore-body, and the red colour is undoubtedly attributable to alteration connected with the quartz veins.

The stock-like body at the Sladen Malartic-Canadian Malartic boundary is similar to and may well connect directly at depth with the quartz syenite porphyry at Canadian Malartic. The body is poorly exposed, so that its outline as shown on Map 575A is largely inferential. However, recent underground work has shown that on the east the mass apparently tongues out very irregularly in greywacke. The west end may be equally irregular. In Sladen Malartic mine the main south contact dips about 65 degrees southward but in detail is tortuous, with vertical or even north dips indicated in places by drilling on Canadian Malartic claims.

No. 1 shaft of East Malartic mine is sunk in a very irregular body of quartz syenite porphyry similar to those at Sladen Malartic and Canadian Malartic mines. A representative core sample was collected from 265 to 290 feet in drill hole No. 24, which cuts the body at a depth of about 200 feet. The sample was analysed by R. J. C. Fabry, with the following results:

SiO_2	64·21
Al_2O_3	16·47
Fe_2O_3	1·78
FeO	1·89
CaO	3·72
MgO	1·18
Na_2O	4·09
K_2O	2·53
H_2O+	0·61
H_2O-	0·02
TiO_2	0·35
P_2O_5	0·69
MnO	Trace
CO_2	1·71
S	0·20
Total	99·45
Less oxygen for sulphur	0·08
Total	99·37

The material analysed consists of albite (An_4) phenocrysts up to 2·5 mm. in diameter in a granular mixture of quartz and albite, with biotite the principal accessory. Muscovite, magnetite, sericitic mica, apatite, and pyrite are minor accessories. The rock is slightly carbonatized.

Recasting the analysis to these constituents gives a rock of the following composition:

Quartz	29·82
Albite (An_5)	36·53
Mica	25·08
Apatite	1·68
Pyrite	0·38
Magnetite	1·39
Ilmenite	0·76
Calcite	3·90
	99·54

The composition of the plagioclase checks satisfactorily with that determined by the microscope and the rock should be termed porphyritic albite granite. The proportion of mica seems higher than indicated by microscopic studies, although there is at least 15 per cent of these minerals in the slides examined. It may be that some of the K_2O should be allocated to potash feldspar in spite of the fact that none was identified in the slides. If, as in the case of the albite granite, the CO_2 and sulphur are disregarded as being introduced, the analysis is recalculated to:

Quartz	28·44
Oligoclase (An_{27})	49·81
Mica	16·70
Magnetite	2·55
Apatite	1·68
Ilmenite	0·76
	99·94

Quartz diorite would be the correct name for such a rock.

SCHISTOSE ALBITE PORPHYRY

Bodies of schistose albite porphyry outcrop with the schistose Blake River volcanic rocks of the Cadillac belt at the Heva River drag-fold and far to the southeast at Rand Malartic mine. Except for the Malartic Lake body of granodiorite porphyry and some dykes of quartz albitite, they are the most highly metamorphosed acidic rocks in the area. They are not unlike the sheared "andesite porphyry" at O'Brien mine and adjoining properties. At Heva River, sill-like to exceedingly irregular bodies, up to 100 feet wide, intrude the greenstones along the south side of the Cadillac belt in the easterly projecting nose of the drag-fold. Albite (An_3 to An_5) phenocrysts up to 3 mm. in diameter are set in a schistose groundmass of quartz, albite, white mica, biotite, and carbonate, and are themselves clouded by flakes of white mica and dust-like particles. Quartz constitutes about 20 per cent of the whole, and the rock is in places traversed by quartz veinlets. Accessories are chlorite, apatite, zircon, iron oxide, and rutile. In some places the rock resembles a schistose arkose and in others an augen schist.

There are outcrops of similar schistose albite porphyry on the Rand Malartic claims in low ground immediately south of the edge of a large hill of greywacke and conglomerate of the Cadillac group. The rock weathers dull grey, like an arkose, and about 50 per cent consists of phenocrysts of albite (An_3). They are bent, broken, sericitized, and up to 2 mm.

in diameter. The groundmass consists of quartz and albite. Sericite and biotite are abundant, and accessories include carbonate, pyrite, magnetite, tourmaline, apatite, and chlorite. No contacts are exposed, but drilling indicates that the schistose varieties are merely sheared phases of relatively massive albite porphyry bodies to the south. These bodies are typical of the feldspar porphyry and quartz syenite porphyry that occurs abundantly in the southeastern part of the area. The schistose porphyry at the Rand Malartic property occurs along the edge of a strong shear zone at the north edge of the Cadillac belt, as proved by diamond drilling. Movements along this shear, after the intrusion of the porphyry bodies, are probably responsible for the schistose character of the intrusive. It is to be noted that the location of the schistose albite porphyry at Heva River, in the nose of a large drag-fold, would suggest a similar explanation of the schistose character there.

ALBITITE AND QUARTZ ALBITITE

Dykes and irregular bodies of albitite and quartz albitite are present in the Cadillac belt across Cadillac township, and are described in some detail in Memoir 206. In Malartic area they are particularly abundant from Lapa Cadillac to Maritime Cadillac mine. There are, however, no exposures of them in that area: all the data concerning them has been obtained from drill cores and underground workings.

The quartz albitite is commonly referred to as aplite. It is a dense, light grey to cream-coloured rock, which weathers white or pale grey to resemble porcelain. An excellent example is the 35-foot dyke at the shaft at Lapa Cadillac mine. Only in a few bodies can crystal grains be perceived by the naked eye. In many places the rock is sheared and altered to a yellowish grey sericite schist closely resembling sheared rhyolite. The more massive varieties consist of albite, a little orthoclase, and quartz. Analyses that show the high soda content are given in Memoir 206.

Dense to porphyritic albitite was encountered in drill hole 13 on the Rubec property, northeast of Lapa Cadillac mine. The hole was inclined northward at 45 degrees and beneath 25 feet of drift passed through 372 feet of albitite before entering greywacke and iron formation of the Cadillac group. Subsequent drilling on the Hayes Cadillac property, 2,100 feet to the east, cut a width of at least 250 feet of identical rock. If the intrusives of the two drill holes belong to one body its strike would be north 85 degrees west, about parallel to the strike of the sediments at this locality. Similar also are porphyry dykes to the southeast at Deane-Cadillac Mining Corporation and on intervening claims held by Sladen Malartic Mines.

The least altered phase of the Rubec albitite is grey, with euhedral phenocrysts of albite (An_3) up to 2 mm. long indistinctly outlined in a fine-grained, crystalline groundmass containing flakes of biotite and disseminated grains of pyrite. Many of the tiny albite crystals in the groundmass are distinctly euhedral. The estimated mineral composition is: albite, 80 per cent; biotite, 15 per cent; the remaining 5 per cent is made up of a little accessory apatite and magnetite and secondary chlorite and carbonate. The rock may be classified as a biotite albitite porphyry.

The drill core shows many altered sections, ranging in length from 2 to 80 feet. The transition from unaltered porphyry to highly altered rock is gradational. In the first stage of alteration biotite is replaced by

chlorite, the albite crystals become turbid and heavily charged with flakes of sericitic mica, carbonate increases in amount, quartz appears as a replacement of the groundmass, and a few tiny rods of tourmaline are introduced. Further alteration turns the rock light yellowish grey, with a few indistinct phenocrysts of albite still visible in the cherty groundmass. In spite of the appearance of the hand specimen the quartz is not notably increased in amount, but sericitic mica makes up to 25 per cent of the whole. In the final stage of alteration the rock becomes porcelaneous or cherty and is cut and replaced by anastomosing veinlets of milky to vitreous quartz.

A little pyrite occurs along some chloritized partings, but sulphides are scarce and the quartz is barren. However, information from one drill hole is necessarily incomplete and unsatisfactory. The management of the Hayes Cadillac property reports finding disseminated pyrite and large crystals of arsenopyrite in silicified greywacke along the north contact of the albitite cut by their drill holes.

Albitite dykes occur at Lapa Cadillac mine and have been encountered in drill holes in the Cadillac belt to the south as far as the Maritime Cadillac property. The rock is aphanitic to finely crystalline and distinctly darker grey than the quartz albitite. Feldspar phenocrysts can generally be perceived by the naked eye. The composition is similar to that of quartz albitite except that there is less quartz. Furthermore, many of the known dykes are mineralized with finely crystalline pyrite, arsenopyrite, and pyrrhotite, and contain gold, though generally in small amount. In drill cores the rock is easily mistaken for dark grey quartz. The rock apparently is not sheared to the same extent as quartz albitite, though it is much fractured in places. At the Lapa Cadillac mine it is found as exceedingly irregular dykes in schist, and in drill holes south of the mine it occurs along or close to pronounced shear zones. It is questionable if small massive dykes of albitite and quartz albitite can be distinguished in drill cores, although the two rocks look very different where seen underground at Lapa Cadillac mine.

Grey to white or pink, aphanitic, porcelain-like dykes that closely resemble the more massive phases of quartz albitite in Cadillac township are found in Fournière township; several were mapped in greywacke south of the Canadian Malartic mine. The dykes attain widths of at least 50 feet. They were not seen in contact with other acidic intrusives. Albite (about An_3) is the principal constituent and there are small proportions of microcline and orthoclase. Quartz is relatively abundant, forming up to 20 per cent of the whole, but the amount varies greatly in different specimens. Albite and microcline form rare phenocrysts up to 1 mm. across in a finer grained groundmass. Accessories are very minor in amount; they include muscovite, biotite, apatite, zircon, chlorite, and rutile. Carbonates, pyrite, and pyrrhotite have been introduced. The texture is remarkably sutured, all the crystals having lacy, interlocking borders. One slide shows cores of turbid microcline bordered and presumably replaced by clear albite. O'Neill has described these dykes under the name aplite porphyry. Reasons for believing the albitite and quartz albitite dykes of Cadillac township to be related to the gold deposits are given in Memoir 206. Little or no evidence for or against such a conclusion is obtainable in

Fournière township, where the dykes may well be the youngest acidic intrusives.

PEBBLE-BEARING LAMPROPHYRE DYKES

A lamprophyre dyke, where exposed in lot 18, range VII, Malartic township, contains many, small, angular inclusions of greenstone, one of rhyolite, and several dozen subangular to well-rounded inclusions of quartz diorite and aplite. The quartz diorite and aplite fragments are undeformed and range from ½ inch to 6 inches in diameter. The dyke rock is non-porphyritic, and is made up of sparkling plates of biotite, usually less than 1 mm. in diameter, acicular green amphibole, and sodic albite (An_3). Other constituents are epidote, carbonate, titanite, apatite, allanite (?), and a little chlorite. Estimated proportions are: feldspar, 35 per cent; biotite, 30 per cent; amphibole, 20 per cent; epidote, 10 per cent; others, 5 per cent.

The rounded, pebble-like inclusions of quartz diorite and aplite probably were stoped from a body of quartz diorite cut by aplite dykes. One of the inclusions consists of the two rock types joined with a welded contact. Quartz diorite of this type is not exposed in the area, but a dykelet of aplite closely resembling the aplite of the pebbles is exposed within 70 feet of the north end of the lamprophyre dyke.

As fragments split off during intrusion must commonly be sharply angular, some cause for the rounding of these fragments must be sought. Mechanical abrasion of the fragments in the magma was probably negligible, because of the relatively small number of "pebbles", the slight differences in specific gravity between them and the magma, and the cushioning effect of the viscous liquid. They must, therefore, have been rounded by partial melting or by chemical action, which should attack the sharp, most easily heated edges and corners with greatest effect. Reaction rims and transfusion phenomena[1] are entirely absent, however, and reaction products or melted material must have dissipated and left the rounded fragments clean to freeze in the apparently homogeneous lamprophyre.

An outcrop 15 feet by 5 feet of almost identical dyke rock was observed in Fournière township, 650 feet south of Malartic township and 100 feet east of the old Cartier Malartic road. The rock contains more mafic minerals than the dyke in Malartic township and yet contains a small amount of quartz. It could be classified as kersantite. The exposure is bordered by drift except on the north where 2 feet of feldspar porphyry adjoins the dyke; the age relations of the two intrusives could not be determined. Within the lamprophyre thirty-eight pebbles were counted. Thirty-five of these are rounded fragments of greywacke; two are of soft mica schist, and one a subangular piece of feldspar porphyry 6 inches by 4 inches. The country rock is greywacke of the Kewagama group.

QUARTZ GABBRO

Only three dykes of Keweenawan (?) quartz gabbro are known in the area. The largest, 150 to 300 feet wide, is in the extreme northwestern part, in Cadillac and Malartic townships. Two series of outcrops there are

[1] Reynolds, Doris L.: Transfusion Phenomena in Lamprophyre Dykes; Geol. Mag., vol. 75, 1938, pp. 51-76.

separated by one mile of drift-covered terrain across which the actual continuity of the dyke cannot be demonstrated. Small subsidiary dykes run off from the main one. The rock consists largley of augite and labradorite (An_{56}). Hornblende, biotite, sericite, chlorite, apatite, ilmenite or magnetite, and epidote are accessories. The texture is ophitic to porphyritic. In at least one locality phenocrysts of altered feldspar up to one inch in diameter are set in a dark, ophitic groundmass. The one thin section examined showed no quartz and no olivine. Similar dykes in Cadillac township contain quartz. As in Cadillac township there are occasional dykes and irregular segregations of feldspathic differentiate—pale grey to pink in colour—that are generally termed aplite.

The second dyke is about 20 feet wide and strikes northeast in the southern part of lot 19, range V, Malartic township. It is of the same composition, but contains a small percentage of quartz. The probable continuation of the same dyke cuts Malartic volcanic rocks in the northern parts of lots 21 and 22, range V, Malartic township. The mineral composition is identical.

The third dyke is about the same size and cuts greywacke in the southern part of lot 8, range II, Malartic township. It strikes east of north. Present in it are spherulitic aggregates of colourless fibres that are tentatively identified as a zeolite, either scolecite or stilbite.

The large dyke in Cadillac township occupies a fissure along which there has been no appreciable displacement, for the contact of sediments and volcanics crossed by it maintains its correct position.

STRUCTURE

GENERAL STATEMENT

Broadly speaking, the Malartic area straddles the contact between a great series of volcanic rocks that, interrupted by large areas of granitic intrusives, extends far to the north, and an almost equally great series of sedimentary rocks to the south. Within the area studied, though the main structural features are fairly well understood, in many places information is too fragmentary to permit detailed solution of the intricate folding and faulting, which, in some places, is undoubtedly of great economic importance.

An attempt has been made in compiling the accompanying maps to distinguish between fact and inference. The locations of outcrops, the characters of the rocks composing them, the structural observations, and information from drill holes are facts; the structural interpretations based thereon are inference. It is not expected or intended that the interpretations shall be accepted as final. Rather, it is hoped that they will serve as useful working hypotheses, to be modified as new information is obtained, or discarded when their period of usefulness has expired.

THE MAJOR SYNCLINE

The concept that the strata are folded into an isoclinal syncline, with vertical or nearly vertical limbs, rests on determinations of the directions in which the beds face. These determinations were based, in the volcanic rocks, on pillows, gradations in size of crystals within single flows, and

gradations in grain size in beds of tuff. In sedimentary beds, the determinations were deduced from gradations in grain size and from crossbedding. 'Fracture cleavage' and drag-folds were not used, for, as shown below, these features were developed by movements later than, and unrelated to, the isoclinal folding; their forms, therefore, are independent of the major structure, and have no bearing on the direction in which the beds face.

Within the Malartic volcanics there are dozens of pillowed flows. The pattern of the pillows, with overlying ones moulded upon those beneath, leaves no doubt whatsoever that the flows, without exception, face south (*See* Plate III). In one or two well-exposed, massive andesite flows the gradation in grain size was sufficiently well developed to allow determination of top according to the method suggested by Cooke, James, and Mawdsley (Memoir 166, page 49). A few massive flows were found, which, across the strike, become progressively finer grained and pass into a breccia 3 or 4 feet thick. The change in grain in the unbrecciated part was interpreted as indicating the top of the flow, and, as with the pillows, all observations showed that the flows face south. Finally, in an exposure near Central Malartic mine some tuff beds 20 feet thick show perfect gradations from coarse breccias on the north to fine tuffs on the south. In short, the Malartic volcanic rocks between the granodiorite sill on Malartic Lake and the Kewagama group on the south all face south.

Within the northern band of the Kewagama group two observations of crossbedding were made: one in lot 15, range VI, the other in lot 21, range V, Malartic township. At both places the beds face south. There and elsewhere the strike and dip are invariably parallel to nearby contacts with the other formations.

Within the Blake River group, in the north limb of the syncline, pillowed flows are well exposed in many places between the west side of the area and range III, Malartic township. Reliable determinations of the attitudes of flows were made at nine places at intervals along this distance, and at every place the flows face south. On the True Fissure property a flow of andesite 30 feet thick gives a perfect illustration of gradations in coarseness of grain within a flow and shows that the top of the flow faces south.

The axis of the syncline falls within the Cadillac group. Its position at the western side of the area, on the Rubec property, is defined by two good determinations based on gradations in grain size, which show that the strata on either side of a small lens of conglomerate face one another; presumably the conglomerate lens occupies the trough of the fold. Eastward the strike of the beds swings south. In three places ½ to ¾ mile west of Revillart Lake crossbedding and grain-size gradation show that the beds face east; these beds are, therefore, west of the axis. From there the continuation of the axis is undefined for almost 2 miles, as far as a series of outcrops in lots 1 to 4, range V, Malartic township. There beautifully crossbedded greywacke affords perfect criteria for determinations of the tops of the beds and the synclinal axis must lie within a strip of low ground 1,000 feet wide, with, curiously enough, a small outcrop of conglomerate again near the middle.

Farther east the structure is more complicated. In lots 13 to 16, range IV, Malartic township, a synclinal axis is indicated for a short distance by beds facing one another, as determined from grain-size gradations. If this is the major synclinal axis it must be folded or faulted a short distance east, for it strikes directly towards a large, drag-folded layer of greenstone, the Little Heva structure, which is not in the axial part of the major syncline. It may be that the beds facing one another are on two sides of a similar drag-fold in the greywackes, a reflection of the Little Heva structure; if so, as the drag-folds plunge vertically, there is no true syncline at all. As in many other critical sections in this area outcrops and data are too incomplete to permit a decision.

A short synclinal axis is defined in lots 3 and 4, range IV, Malartic township, by grain-size gradations and crossbedding. This axis may extend eastward as far as the line between ranges III and IV, where good determinations show that the beds face north. If it does, it is probably the axis of the main fold. However, it cannot join directly with the main axis on the Valco property; it may have been moved westward along an east-west fault into its present position. Within the strata of the Cadillac group southeast of range III, Malartic township, no information as to the location of the axis could be obtained. Presumably it lies somewhere about the middle of the narrowing strip of these sediments.

Observations indicating the attitudes of tops of beds were also made in several other places within the area of the Cadillac group on the south limb of the fold. In outcrops just east of the road to the Lartic mine good crossbedding shows that the beds face north; on the ridge near the Dempsey-Cadillac camp buildings, grain-size gradation indicates that the top of a bed faces to the north.

Within the south band of the Blake River group the forms of pillows in two exposures of pillowed lavas, one in lot 22, the other in lot 24, range I, Malartic township, show that the tops of the lava beds face north. Some poor pillows in a flow exposed near the old Sladen camps, though scarcely good enough to be diagnostic by themselves, seem to indicate that this flow faces north.

Within the southern area of the Kewagama group, crossbedding and grain-size gradations in fifteen or twenty places at intervals from the Maritime Cadillac to the Sladen Malartic property all agree, and show beyond doubt that except in locally drag-folded areas the beds face north. Thus the combined evidence from crossbedding, gradation in grain size, and pillows establishes the existence of the major synclinal fold.

With the syncline established, the question at once arises as to why the volcanic rocks of the Malartic group fail to appear on the south limb. If the folding were simple, they should outcrop a few thousand feet south of the southern band of the Blake River group, but no volcanic rocks were discovered by James and Mawdsley anywhere between the band of the Blake River group and the edge of the southern batholiths, 3 to 10 miles farther south; this area, so far as known, is underlain solely by sedimentary and granitic rocks. The structure of the area is unknown. Presumably all the strata belong to the Kewagama group, and it is suspected that they are much thicker than on the north limb of the major syncline. This thick wedge of sediments may have been considerably less competent than

the underlying Malartic volcanic rocks, with the result that, whereas complex isoclinal folds developed in the sedimentary strata, only gentle, open folds were produced in the volcanic rocks. The net result would be that a great vertical thickness of intensely crumpled sedimentary rocks would pile up upon the volcanic rocks and so, at the present level of erosion, keep them hidden.

Towards the east the two bands of the Blake River group gradually approach one another and the intervening space narrows from 3 miles to less than 1 mile, an indication that the major syncline plunges gently westward. East of the area, bedrock is covered by deep drift and sand for several miles and rock outcrops are practically unknown. The known distribution of the Blake River rocks suggests that the two bands should meet on the nose of the fold somewhere near or east of the Fournière-Dubuisson township line. The western extension of the syncline is shown in Map 399A, Memoir 206. As shown there, it crosses Cadillac township and is open at the west end.

THE CADILLAC "BREAK"

The Cadillac "Break" is a feature of great structural and economic significance. It is a zone, presumably formed by faulting movements, of soft chlorite and talc schists with thin layers of muddy gouge. It lies within the southern band of the Blake River group, extends across the Cadillac area, and, as shown below, presumably across the Malartic area as well. The zone ranges in width from a few feet to 150 feet or even more and has a steep southward dip. It does not outcrop except where parts of it have been exposed in a few trenches. Its surface expression is commonly a narrow, swamp-filled, linear depression. Gunning was able to trace the "Break" continuously across Cadillac township as far east as Pandora mine through mine workings, diamond drill holes, and topographic expression. East and southeast of Pandora mine the information is less complete. Diamond drilling and more recent underground work at Lapa Cadillac mine has revealed several zones of soft schists, any one of which may be the Cadillac "Break". Similar zones of chlorite schists have been intersected in diamond drill holes on the Dunlop and Maritime Cadillac properties. From there southeastward for 2 miles little work has been done on the area of the Blake River group, and typical soft schists are next encountered at the nose of a sharp drag-fold on Pan-Canadian property. There a zone of schists 50 feet wide is exposed in a deep trench along the north side of the greenstones within the fold. Diamond drilling on Dempsey Cadillac ground just off the east end of the drag-fold has shown that the shear zone probably does not continue in that direction. It is not improbable that it was drag-folded around with the greenstones, its place on the south side of the fold being now filled with the body of schistose porphyry that outcrops there. Southeastward on the southern part of Pan-Canadian ground the schist zone passes under a narrow gully on the south side of the lavas southwest of the No. 2 shaft, and is picked up in diamond drill holes south of the No. 1 shaft

and again in diamond drill holes in range III, just east of the Cadillac-Malartic township line. From there, no information is available for 2 miles, until the Partanen property is reached. There diamond drilling shows a wide zone of chlorite schists along the south side of the Blake River group. This is followed by another gap, of 3¼ miles, southeast to the old Sladen camps, where a deep, swamp-filled gulch on the south side of a deep-walled outcrop of greenstone may mark the continuation of the "Break". Recent drilling (1937) on the East Malartic and Sladen Malartic properties has shown a wide zone of intense shearing along the south side of the Blake River group. Similar conditions are shown by drilling at the same contact 2½ to 4 miles farther east at the Rand Malartic and Malartic Goldfields properties. It might be assumed from all this that a single zone of intense shearing extends along the south side of the Blake River group all the way across Fournière township, but the situation is complicated by other facts. At East Malartic No. 2 shaft the volcanic rocks are converted to soft chloritic schists, more or less like those found in the Cadillac "Break", but the sheared rocks lie at or very close to the north contact of the Blake River group. At No. 1 shaft, well within the Blake River group, the rocks near a large intrusive body are similarly schistose, and faulted. Finally, on Rand Malartic ground, diamond drilling has demonstrated the existence of a zone, 100 feet wide, of soft, chloritic schist at the north contact of the Blake River group. These facts show clearly that intense shearing is not limited to any one well-defined horizon in this part of the area.

The writers conclude that these shear zones with chloritic schist, found at intervals within the southern band of the Blake River group all across the area, are indicative of faulting, although in no case has the amount or direction of displacement been determined. At and southeast of the Pan-Canadian property there may be such a fault all along the southern part of the greenstone belt, but in Fournière township, at least, there are other shear zones in the greenstone. The conclusion seems reasonable that a major fault, the Cadillac "Break", may persist across the area. If it follows the southern side of the Blake River group and does not swing back and forward across the greenstone band, then there are other similar faults within the band that may be subsidiary or complementary to the main one. The band of volcanic rocks seems to have acted as an incompetent layer that broke down with relative ease to slippery chloritic schist. Once formed, the schist would act as a lubricant to facilitate and localize any further movement. Study of the metamorphism of the rocks on either side of the fault zone, although not as convincing as might be desired, suggests that the south side moved up with respect to the north.

Most of the promising mineral deposits of the area have been found in or near the Cadillac "Break". Many small dykes and plugs of feldspar porphyry and albitite occur in or near the Break", and a reasonable interpretation of this whole association is that the fault reached deeply enough to act as a structural control, first for the intrusion of dykes, and, second, for the entrance of mineralizing solutions.

DRAG-FOLDS

The drag-folds in the area fall into two groups, both formed by nearly horizontal movements. In the first group the plan of the folds is Z-shaped, so that the north or northeast sides moved east with respect to the south or southwest sides; folds of this type are developed in the strata of all the rock groups. The second group is developed in the southern band of the Kewagama sedimentary rocks in the southeastern part of the area; the folds are S-shaped, so that the north side moved west relative to the south.

Z-SHAPED DRAG-FOLDS

Z-shaped drag-folds range in size from the big bend in the synclinal axis near Révillart Lake down to a few feet in length. The Révillart Lake bend in the major structure is clearly indicated by the swing in strikes east and west of the lake. A curious feature is that, southwest from Révillart Lake, the degree of folding and contortion increases from the simple, smooth bend in the Malartic group to the highly contorted and faulted strata around and south of Lapa Cadillac mine.

Small drags are best developed in magnetite beds, iron formation, or argillaceous beds, but even some layers of conglomerate 40 feet thick have been twisted into sharp folds, as on the hill on the Cadillac-Malartic township line, ranges V and VI. The plunge of these folds is invariably steep, in most cases nearly vertical. As the plunge of the major syncline is very gentle, the axes of the drag-folds are nearly perpendicular to the axis of the major fold. Therefore, the drag-folds cannot have developed by the nearly vertical slippage of the beds as the syncline formed. Furthermore, Z-shaped folds occur on both limbs of the major structure, which would also be impossible if they had formed as a result of the main folding. They were developed after the main folding; that is, after the strata had been thrown into vertical positions, the beds slipped past one another as a result of nearly horizontal movements.

A large drag-fold was first discovered in underground workings of the Pandora mine.[1] Three others, all somewhat larger, have since been found in the Malartic area. They have been named the Lapa Cadillac, the Heva River, and the Little Heva River structures.

Lapa Cadillac Structure

The area of the Lapa Cadillac drag-fold includes the Lapa Cadillac, Maritime Cadillac, and Dunlop Consolidated properties. The drag-fold, as outlined by a few exposures and by diamond drilling, consists, apparently, of two large, sharply contorted and sheared bulges in the southern band of the Blake River group. Where the band enters the drag-fold from the west it is only 150 feet wide. Proceeding eastward, a few outcrops and drilling on the property of Zulu Gold Mines indicate that the band thickens and consists of interbedded volcanic and sedimentary rocks, all sheared and highly altered, intruded by bodies of albitite and quartz albitite. At

[1] Mem. 206, p. 27, and Figs. 4 and 5.

Lapa Cadillac mine the width is at least 750 feet and the rocks are mica and chlorite schists. The southern 350 feet of these schists are probably altered lavas. The north contact of the band as indicated on the map is arbitrarily placed due to lack of information. East and southeast of the mine there is a large drift-covered area in which the nose of the fold must lie, as outcrops of the Cadillac group beyond it preclude the continuation of the greenstone band in that direction. The contacts in this drift-covered area are arbitrarily placed, and perhaps the structure is more complicated than is indicated. The outline of the drag-fold south and southwest of Lapa Cadillac mine is moderately well known from outcrops and diamond drill holes. An area measuring at least 2,000 by 3,000 feet is underlain by massive to highly sheared volcanic rocks and interbedded sediments. Several strong shear zones, any one of which may be a major fault, are known. Where it leaves the drag-fold area, south of the Maritime Cadillac property, the band of Blake River rocks contracts to a thickness of 500 feet or less. How much of this apparently great thickening and thinning is due to original differences in thickness, to flowage during folding, to interfingering of greywacke and greenstone, or to repetition of beds by folding or faulting, is something that as yet cannot be even roughly estimated. A cross-fault striking north 57 degrees east on Maritime Cadillac ground is postulated because otherwise it seems almost impossible to accommodate the known strikes of the rocks and carry the known width of greenstone southward through the narrow gaps between outcrops of the rocks of the Cadillac and Kewagama groups. Furthermore, a parallel minor fault, with the same direction of displacement, was found in the Cadillac group just to the south.

One interpretation of the Lapa Cadillac structure is offered on Map 575A, but it is admittedly only a guess that fits the known facts. In a preliminary report (Paper 36-9) another interpretation with an east-west fault was shown. The correct solution may be quite different from either. Some of the shear zones discovered within the greenstone belt may be major faults that offset the whole structure.

Heva River Structure

The Heva River structure lies where the southern band of the Blake River group crosses Heva River one mile west of Malartic township. The continuity of the band of volcanic rocks betwen this and the Maritime Cadillac property is established by two exposures of greenstone along the river and by the trend of strata in the adjoining Cadillac and Kewagama groups. Within the drag-fold area outcrops are scarce, particularly in critical places. The largest exposures of greenstone form part of a prominent ridge just south and east of Heva River. The altered lavas and tuffs are separated from greywacke on the north by a zone of chlorite schist 50 feet wide and on the south by a dyke of sheared feldspar porphyry up to 80 feet wide. Diamond drilling on Dempsey Cadillac ground east of the nose of the fold has shown that the greenstone does not continue in that direction. Either it was carried into its present position along an east-west fault or it is folded back on itself, as shown on Map 575A. If the east-west fault exists it is now occupied, at least across the ridge, by the porphyry dyke.

Little Heva Structure

The assumed structure in the northern band of the Blake River group is the largest drag-fold in the area, and the one about which least is known. It is outlined by a group of exposures in lots 15 to 28, ranges III and IV, Malartic township, but most of the exposures are small, and are not in the critical places. One interpretation of the available data is offered on Map 575A; a not less probable interpretation, in fact one more satisfactory in some respects, is given in Figure 5 and involves an east-west fault of considerable displacement, which might connect with the possible east-west fault across the Heva River drag-fold.

The north limb of the drag-fold is offset by at least three cross-faults, striking 30 to 45 degrees east of north. None of the faults is exposed, but the distribution of the rocks, and the strikes of the various contacts are such that they, or analogous ones, are necessary. For example, the eastern extensions of a thick sill of quartz diorite and the flow of amygdaloidal lava described under the Malartic volcanics are apparently offset 1,000 feet or more to the south. Estimated horizontal displacements on the faults range from 150 feet on the western to 900 feet on the eastern, on each, the east side moved south with respect to the west.

Smaller Drag-folds

Drag-folds with amplitudes of a few hundred feet are exposed in several places in the area, but of these only two are known to have features of particular interest. In lot 21, range VII, on the Malartic Lakeshore property, the east end of a lens of conglomerate and greywacke is bent sharply southward. Details of the structure are included in the description of the property. The second is an extraordinarily complicated little fold, fairly well exposed in the south halves of lots 18 and 19, range V, Malartic township. Because the exposures are considerably better than average an attempt was made, by mapping on a scale of 1 inch to 200 feet, to solve the structure in detail. In spite of this the results were not conclusive. The distribution of the rocks is shown in Figure 3. The difficulty encountered in attempting to solve this comparatively well exposed structure emphasizes the fact that interpretations offered for the larger drag-folds must be accepted with caution.

S-SHAPED DRAG-FOLDS

Drag-folds S-shaped in plan are known principally in strata of the Kewagama group at and southeast of the old Cartier Malartic mine. The folded area at that property and another at Canadian Malartic mine were mapped with special care. The beds in the intervening area are also folded, but exposures and data are insufficient to show whether or not the folds at the two places are part of a single fold. Details of the geology in the two areas are given in the descriptions of Canadian Malartic mine and the holdings of Amphi Syndicate, and are illustrated in Figures 2 and 7. The drag-folds plunge steeply or vertically; they were formed by horizontally directed movements that carried the northeast sides northwest.

Why the major drag-folds in this one part of the area should be S-shaped and those in other parts Z-shaped is unknown. Neither type, as shown by the very steep plunges, can be related to the synclinal folding. The Z-shaped ones were formed by movements acting in a clockwise sense; the S-shaped set by movements acting counter-clockwise. Although the Cadillac "Break" is affected by the Z-shaped folds, none of these folds occurs south of it nor are any major S-shaped folds known north of it. Possibly the S-shaped folds are related to movements along faults that trend west, away from the Cadillac "Break", in the southeastern part of the area. Such faults are known in the Sladen and Canadian Malartic mines, and there may be others in the drift covered parts of this part of the area. Furthermore, there may be some structural relation between the S-shaped folds and the porphyry intrusives that occur in some abundance near them. Whatever the explanation, the areal distribution of the different types of drag-folds is of importance to mineral development of the region. Only a few very minor S-shaped drag-folds were noted in the country north of the Cadillac "Break." They are mere kinks in the bedding planes, and are nearly always associated with northerly trending, oblique faults of small, left-hand displacement. Thus, except in form, they are not to be compared with the large drag-folds of this kind in the southeast part of the area.

FAULTS

Mention has been made already of the Cadillac "Break" and similar zones of intense shearing that occur along the south band of the Blake River volcanic rocks. They parallel the bedding, and in no case has the amount of displacement along them been determined, though it is suspected that the "Break" is a major fault. Attention has also been called to the possibility of faulting in connection with the drag-folds. In addition, there are oblique faults that cut across the strike of the strata.

OBLIQUE FAULTS, EXTENSIONAL

All oblique faults of appreciable offset observed in the field are shown on the accompanying maps, and also a few inferred but not directly observed. In addition to those large enough to map, there are many minor ones, with displacements of a few inches to a foot or two. The commonest type of oblique fault strikes in the northeast quadrant, from about north 30 degrees east to north 65 degrees east. The horizontal displacement is left hand, that is, the beds on the northwest are displaced to the southwest relative to those on the southeast. The largest proved displacement is 40 feet, on a fault in lots 1 and 2, across the V-VI range line, Malartic township. Several others were observed in lots 23 and 24, range V. Another was traced for nearly 1,200 feet in lots 15 and 16, range VI. It strikes north 65 degrees east and, like all the others, is nearly vertical. In it, and in several of the faults in range V, there are small veins of white, cavernous quartz that in places carry a little pyrite. The left hand displacement at the west end of the fault in range VI is 10 feet, but 1,000 feet to the east it is only 3 feet. A northeasterly

striking, left-hand fault cuts greywacke near the north end of lot 19, range 5. The exposures are not good, but it seems probable that the fault has offset the contact between the Kewagama and Blake River groups about 200 feet. If so, it is the largest displacement observed in the area on this type of fault.

Two faults with appreciable right-hand displacement, and a number of others with very small displacements, probably belong to a type complementary to that described above. One lies north of the highway at Lapa Cadillac mine, strikes practically due north, and offsets a prominent band of iron formation 75 feet. The other offsets the large quartz diorite dyke on the west side of lot 18, range VI, Malartic township, 300 feet. This fault may be the continuation of one with similar displacement that crosses the drag-fold in lots 18 and 19, range V. In range VI its strike is north 10 degrees west.

Possibly these two types of faults belong to one system. They may correspond to the northeast and northwest faults in Cadillac township (Memoir 206, page 29), and may have been formed by forces that tended to extend the beds approximately along their strike.

OBLIQUE FAULTS, COMPRESSIONAL

The system of faults described above produces lengthening of the area affected by them. Other faults in the area have the opposite effect. Several, all inferred from detailed mapping, occur in the Little Heva River drag-fold, and two, a small observed one, and a larger inferred fault with offset of about 850 feet, are shown on the property of Maritime Cadillac Gold Mines. All strike from north 30 degrees east to north 60 degrees east and the displacement is right hand, the southeast side being displaced to the southwest. In the northern part of Malartic township faults of very small displacement were observed; they strike nearly due north, and the offset along them is left hand. In every case the strata adjoining the fault are bent or dragged by the movement along the fault, and the dip of the fault planes is nearly vertical. In the same part of the area other faults of very small displacement, also with the strata bent against them, strike northeasterly and have right-hand offsets. All these minor faults are, in essence, tiny faulted drag-folds; in this respect they differ distinctly from the first described system of faults, which has no relationship to drag-folding.

The above facts suggest that a second system of faults is developed in the area, striking nearly parallel to the first system but with displacements in opposite directions. However, apparently only the northeasterly, right-hand representatives of this system have produced displacements of more than a few feet. The facts also suggest that the system was developed by the stresses that produced at least some of the steeply plunging drag-folds in the area. A horizontally directed force, tending to carry beds on the northeastward past those on the south, could produce the Z-shaped drag-folds and right-hand northeast faults, as well as bedded shears and faults. If, in some parts of the area, the resultant forces produced simple compression along the strike of the beds, north-striking faults with left-hand displacement and S-shaped drag-folds might develop.

SLADEN MALARTIC NORMAL FAULT

An easterly striking zone of faulting and brecciation is well exposed in Sladen Malartic mine, can be identified in parts of Canadian Malartic mine workings, and probably continues eastward to the south contact of the Blake River group not far west of the East Malartic boundary. In Sladen Malartic mine the most pronounced and continuous fault plane in this zone dips south at 65 to 75 degrees; movement along it was normal and later than the period of mineralization that produced the auriferous deposits. However, initial movements along this zone were somewhat earlier, for brecciated porphyry and greywacke have been silicified and mineralized.

SHEAR ZONES

In addition to the Cadillac "Break" there are many smaller shear zones whose origin is obscure. A number of them are shown on the accompanying maps. Some parallel the bedding and die out in relatively short distances along their strike, without any apparent displacement of the adjoining rocks. Others crosscut the strata, as on lots 15 to 20, ranges IV and V, Malartic township (*See* Figure 3). The strike of the bedding here is approximately 40 degrees west of north; the strike of the shear zones ranges from 60 to 65 degrees west of north. Their widths vary from 2 to 10 feet, and one was traced for 450 feet. They are filled with schist apparently derived from rocks similar to the present massive wall-rocks. The cleavage planes dip vertically or very steeply, and are parallel to the walls of the zones. In spite of a fault-like appearance there appears to have been little displacement, though it is difficult to prove this on account of the lack of good horizon markers. However, disregarding the puzzle of their origin, these minor shear zones are of interest economically, as some of them are pyritized and others occupied by quartz veins.

METAMORPHISM

Metamorphism of the rocks in the Malartic area, excluding hydrothermal alterations associated with intrusives and ore deposits, produced changes of two general types; first, mechanical, and second, mineralogical. The mechanical changes include development of linear structures by elongation of such elements as pebbles, nodules in flows and mineral grains, drag-folding, and, probably, the development of schistosity. Mineralogical changes consist mainly of recrystallization of the original minerals into new minerals more nearly in equilibrium with the physical environment at the time of metamorphism.

MINERALOGICAL CHANGES

The mineralogical constitution of all the rocks has been changed more or less completely since they were laid down. As shown in Figure 6, they can be divided mineralogically into two main groups, one characterized by albite as the only feldspar, and the other by a plagioclase that ranges from oligoclase to andesine (An_{20} to An_{32}).

ALBITE GROUP

In the albite group, in most of the sedimentary and some of the acidic volcanic rocks, the other essential minerals are quartz, biotite, chlorite, white mica of sericitic habit, epidote, and magnetite. In more basic sedimentary rocks and most of the volcanics the main differences are a lesser amount of quartz, much less biotite and white mica, more chlorite and epidote, and the addition of pale actinolitic amphibole. This simplicity of mineral constitution is most remarkable when the wide diversity of origin of the rocks concerned is considered. In basalts, andesites, rhyolites, trachytes, older quartz diorite, greywackes, and conglomerates, albite is practically the only feldspar and actinolitic amphibole provides the only variant in the suite. All the original differences that must have existed have been eliminated, and a simple uniform suite of minerals produced. Such uniformity indicates that the rocks, at some stage in their history, all reached an environment in which only the minerals now present were stable. As a consequence any other minerals that may have been present broke down into, or reacted with one another to form, the present stable varieties. The several species thus produced are of types formed at moderate pressures and temperatures.

The minerals, with the exception of some clastic quartz grains, crystallized after schistosity developed. Sieve textures and sutured borders are universal, and although many biotite plates and prisms of amphibole are oriented at random across the planes of schistosity, all the minerals, except in rocks in later narrow shear zones, are undeformed.

An interesting illustration of the relative rates of growth of large biotite crystals was observed during search for tops by grain-size gradation in single beds. At Dempsey Cadillac mines in an outcrop of greywacke, the lower 2 or 3 inches of each of a pair of beds is medium- to fine-grained greywacke with clastic quartz grains 0·2 mm. or so in diameter. This grades upwards into very fine, argillaceous material, also 2 or 3 inches thick, with quartz grains 0·01 mm. or less in diameter. However, the fine-grained, argillaceous top is thickly sprinkled with biotite crystals to 0·5 mm. in diameter, in marked contrast with those in the coarser bottom when the biotite flakes about equal the quartz grains in size. As in the other rocks in the area, sieve textures and sutured borders of the biotite flakes indicate beyond doubt that they are actually secondary and not original constituents. The size distribution of the biotite flakes illustrates the familiar principle that one of the main factors controlling the speed of a reaction is the fineness of subdivision of the reacting substances. The more finely divided the material the more surface is exposed, so that reaction, once initiated, can proceed more rapidly towards completion.

The situation described has another important application. One of the methods most commonly employed for determination of the tops of beds is observation of gradation in grain size from coarse at the bottom to fine at the top. However, in the beds illustrated, the net effect of alteration has been to produce a complete reversal of the grain size in so far as the biotite flakes are concerned. At first glance the lower side might easily be mistaken for the top. Apparently a very similar situation was discovered by Read in the Dalradian rocks of Banffshire.[1]

[1] Read, H. H.: Dalradian Rock of Banffshire; Geol. Mag., vol. 73, 1936, pp. 468-486.

He describes beds 6 inches to 1 foot thick in which andalusite crystals are present in the argillaceous and absent in coarser grained parts. The argillaceous parts, as determined from other independent criteria, according to Read, form the tops of the beds, and he points out (page 473), "Further, since the andalusite occurs as large porphyroblasts, the top, which was originally the finest part of the bed, becomes on metamorphism, the coarsest grained portion." Although it is perhaps doubtful whether the finest grained part would ever become *uniformly* the coarser grained, the point is well made that care must be exercised if the correct interpretation of top in rocks of this type is to be made from grain size observations.

OLIGOCLASE-ANDESINE GROUP

The distribution of this group is shown in Figure 6. With two exceptions the examples are derived from sedimentary rocks, either greywackes or conglomerates. The most conspicuous differences between hand specimens of this group and those of the albite group is in the development of mafic minerals. Cleavage faces in most varieties shine with brilliant plates of biotite 1 or 2 mm. in diameter; in other, more basic varieties, amphibole crystals to ½ cm. long accompany biotite and in some exceed it in amount. Other differences, which appear in thin section, are a greater uniformity in grain size, virtual absence of chlorite (with the exception of those that appear to have retrogressed), and restriction of white mica to a few tiny flakes in feldspar grains. Amphibole, where present, tends to form crystals with euhedral cross-sections but irregular terminations. It is a variety that, although reported from unmetamorphosed igneous rocks, seems to be more typical of metamorphic rocks. Its optical properties are: Z agains c′, 17 degrees to 21 degrees; (—); 2V, 65 degrees to 75 degrees; strongly pleochroic with X, yellowish, Y, olive green, Z, distinctive greenish blue; absorption, Y equal or greater than Z greater than X. Investigations to date are incomplete, but they indicate that the amphibole is in a series with actinolite.

The feldspar ranges from oligoclase (An_{20}) to andesine (An_{32}), is practically untwinned, but has fairly well developed cleavage in most grains. The grains tend to be equidimensional, and here and there a few have grown to considerable size. The larger ones have deeply sutured borders and sieve textures; though most are clear, a few are turbid and flecked with white mica.

Garnet was discovered in only one specimen, collected on Don Martic property about 1½ miles west of Canadian Malartic. It occurs in small anhedral grains, each surrounded by a mat of biotite.

RELATIONSHIPS OF THE ALBITE AND THE OLIGOCLASE-ANDESINE GROUPS

Studies of metamorphosed rocks of this type in other areas have shown that where metamorphism becomes progressively more intense, either along or across the strike, they can be subdivided into zones of differing metamorphic grade. Five zones are in common use; from lowest

to highest they are the chlorite zone, biotite zone, garnet zone, kyanite zone, and sillimanite zone. The mineral after which each zone is named makes its first appearance at the transition from a zone of lower grade to the zone that it characterizes.

Albite is the characteristic feldspar in the chlorite and biotite zones; oligoclase-andesine is equally characteristic of the garnet zone. As the degree of metamorphism is raised from the biotite to the garnet grade, the increased temperatures and pressures initiate a reaction between albite and epidote that produces a more calcic feldspar, ordinarily about An_{30}. A feature worth noting is that although the zone is named the garnet zone, garnet may or may not appear, depending, in part at least, on the composition of the rock. Other mineralogical anomalies, such as failure of albite to change to a more calcic plagioclase, may be due to lack of enough calcium-bearing mineral to react with it. Interpretation of the metamorphic grade can in some cases be made from the other minerals in the suite, especially where a gradational progression can be traced either in the rocks in question or in adjacent, more amenable types.

The transition from one zone to another, though it may be accomplished within a relatively short distance, is normally a progressive change, which ordinarily can be observed in the field.[1] However, where the contact between the albite and the oligoclase-andesine groups can best be observed in this area, near Pan-Canadian, there is no transition zone whatever; rocks of the albite group abut against the north side of the Cadillac "Break", those of the calcic plagioclase against the south side of the "Break". The intervening 100 feet or so of the "Break" is composed, as elsewhere, of pulpy chlorite schists. Thus at this locality the Cadillac "Break" appears to be a fault of enough displacement to cut out the transition rocks entirely, and, as the southern rocks are those of higher rank, it appears reasonable to assume that they have moved upwards on the fault with respect to those on the north. But, as Figure 6 indicates, the distribution of the two varieties elsewhere is so erratic, with representatives of the oligoclase-andesine group appearing far north of the Cadillac "Break" and of the albite group well to the south, that the suggested interpretation seems impossible.

RETROGRESSIVE METAMORPHISM

Some specimens that contain oligoclase or andesine, particularly those taken south of Pan-Canadian, contain chlorite as the only mafic mineral. This chlorite instead of being clear and in clean-cut flakes, as in the albite group, forms a mat of dirty appearing material with rutile needles and tiny grains of magnetite distributed thickly through it. The feldspars are turbid and heavily charged with flakes of white mica. No completely diagnostic criteria of retrogression were discovered, but the

[1] Ambrose, J. W.: Progressive Kinetic Metamorphism in the Missi Series near Flinflon, Manitoba; Am. Jour. Sci., vol. 32, 1936, pp. 257-286.

appearance and matted habit of the chlorite, its association with calcic plagioclase, and the condition of the plagioclase itself, suggest that the rock has retrogressed from a somewhat higher grade of metamorphism, possibly from a quartz-biotite-oligoclase schist.

The alteration, that is, the retrogression indicated in the specimens collected south of Pan-Canadian, does not appear to be related to action by intrusive bodies. At least there are no intrusives exposed nearby, and distinctive hydrothermal minerals are absent from the suite. However, some of the specimens collected near the Cartier Malartic intrusive, and possibly some of these near Canadian Malartic, may have been hydrothermally altered, for carbonate and pyrite are common constituents.

CHAPTER II

MINERAL DEPOSITS

Gold is the only metal found in commercial quantities in the area. With it in most desposits is silver in variable proportions. Arsenic could be extracted as a by-product from some deposits. The area forms part of the Southern Gold Belt of Rouyn-Bell River region. On the west it is bordered by the Cadillac-Bousquet gold area and on the east by the highly productive Dubuisson-Bourlamaque field. The gold deposits of Cadillac township are described in some detail in Memoir 206 of the Geological Survey, Canada, which should be referred to as a supplement to this report.

Mining activity dates from 1923, although sporadic efforts at prospecting had been made for years before that. In 1923 gold was discovered in Fournière township at the Goldie and Canadian Malartic properties. At about the same time the late Mr. Joe Lewis discovered auriferous quartz veins on what is now the property of Maritime Cadillac Gold Mines. Following these discoveries the area was subjected to more intensive search and other deposits were found. The O'Brien mine, west of the area, was discovered in 1924. Activity continued until 1929, and underground operations were established at Canadian Malartic, Goldie (Lucky Tiger), Laurentian (Cartier Malartic), Lartic, and Malrobic. The depression of 1929, coupled with disappointing results at Canadian Malartic and Goldie, effectively dampened enthusiasm, so that practical quiescence continued until 1933. The increase in the price of gold that year resulted in the reorganization and reopening of Canadian Malartic Gold Mines. Activity increased and continued after the stabilization of gold at $35 an ounce. By 1935 Sladen Malartic Mines and East Malartic Mines were undertaking extensive developments and operations were instituted at Pan-Canadian and Lapa Cadillac. The activity then, however, was slight compared with that that followed the discovery of a new and phenomenally rich shoot of ore at the O'Brien gold mine in April 1936. During that year, also, satisfactory progress was made at East Malartic, Sladen Malartic, and Lapa Cadillac mines; Canadian Malartic mine continued as a producer, and a small but unusually rich vein was discovered on Pan-Canadian ground. At present practically the entire area considered in this report is staked and much development work is being done. In 1937 Canadian Malartic mine was still the only producer, but in 1938 mills at Sladen Malartic, Lapa Cadillac, Pan-Canadian, and East Malartic mines were placed in operation. The Pan-Canadian mill ceased operation late in the year.

GENERAL CHARACTERISTICS OF THE PRINCIPAL DEPOSITS

Within the area there are two main groups of gold-bearing deposits. The first, exemplified chiefly by deposits in Cadillac township, is distinguished primarily by the presence of arsenopyrite. The second, found chiefly in Fournière township, contains no arsenopyrite. There are other important differences, as will be shown, and within each group are several

types of ores. Some deposits cannot be classified readily as belonging to either group, but they are relatively unimportant. The ores of Lapa Cadillac mine, the high-grade vein at No. 2 shaft of Pan-Canadian mine, and a host of less important occurrences to the east of these represent the Cadillac type of deposits. The ore-bodies of Canadian Malartic, East Malartic, Sladen Malartic, and other properties near these mines represent the Fournière type.

Typical of the Cadillac type deposits are dark grey quartz veins remarkable for their spectacular shoots of native gold. Associated with the veins are variable amounts of arsenopyrite, pyrite, and pyrrhotite, and very minor amounts of galena, chalcopyrite, and zinc blende. Arsenopyrite is the distinctive metallic mineral and is an invariable associate of all the commercially attractive deposits discovered. Other minerals are black tourmaline in very variable amount, brown biotite, sericite, albite, chlorite, scheelite, and ankeritic carbonate. The veins are markedly lenticular and are generally narrow, 3 or 4 feet of quartz being considered a very good width. However, in some places the width of minable material is greatly increased by the presence of mineralized, auriferous wall-rock, replaced by one or more of the above-mentioned non-metallic minerals, and impregnated or, in places, almost completely replaced by pyrite or arsenopyrite. There are all varieties of this type of material, from narrow or wide layers of altered rock on the walls of quartz veins to zones of such rock traversed by quartz stringers, and to large, irregular bodies, such as some of the ore at Lapa Cadillac, in which there is little or no vein quartz. As a rule tourmaline is not abundant in the quartz veins, but it is probably always present. It is the black, iron-rich variety and its preferred habitat is the wall-rock adjoining quartz. Some "veins" of dark, greyish brown quartz at Lapa Cadillac mine are unusual in this respect. They carry free gold and the unusual colour is due to much disseminated, very fine-grained tourmaline. The character of these deposits suggests that they are due to replacement of schist rather than to fissure-filling. Certain veins and siliceous replacement zones in the northern band of the Blake River group in Cadillac township are also excessively rich in tourmaline, and greywacke adjoining narrow quartz veins at the western end of range V, Malartic township, is extensively replaced by black tourmaline. Sizeable bodies of massive black tourmaline, with some vein quartz and much coarse gold, have recently been developed at the Central Cadillac mine, and masses of pyrite in the same mine are also auriferous. With these and a few other exceptions tourmaline is present in relatively small amount, but may be regarded as a mineral diagnostic of the Cadillac type of deposits. The senior author has given reasons elsewhere[1] for believing that deposits of the Cadillac type were formed at great depth where the temperature gradient of the ascending mineralizing solutions was low, and that, consequently, no sudden changes in the type of mineralization should be expected at depth.

The deposits in Fournière township show greater diversity than do those in Cadillac township. Gold is found in a wide variety of structures,

[1] Geol. Surv., Canada, Memoir 206, p. 39.

with differing mineral associations, in an area of exceedingly few outcrops where mining development is just beginning. Perhaps the most striking mineralogical contrast to the Cadillac type is the absence of arsenopyrite. The principal sulphide is pyrite. There are also small percentages of galena, sphalerite, chalcopyrite, and at least two tellurides, sylvanite and possibly petzite. Pyrrhotite is remarkably rare. The gold is free and generally so finely divided as to be invisible to the naked eye, although coarse gold does occur. Typically the deposits are low grade and are adapted to large scale mining operations, in marked contrast with the rich and relatively small veins of the Cadillac type. At least five entirely different types of ore are known and are being mined in Fournière township; and there are in addition several other types of mineralization which, up to now, have not been found to carry commercial values. The five main ore types are as follows.

(1) Pegmatitic veins, made up of white to watery, coarsely crystalline quartz and albite, with minor amounts of white mica, biotite, chlorite, pyrite, chalcopyrite, molybdenite, purple fluorite, black rutile, scheelite, specularite, and, rarely, garnet and tourmaline. These veins grade in places into ordinary quartz veins. They carry rather high values in gold, generally between $10 and $30 a ton. So far they have been found only in the deeper levels of the Canadian Malartic mine, where they cut quartz syenite porphyry. Both the feldspar of the veins and the adjoining porphyry are pink or brick-red, due to inclusions of finely divided hematite. The relations somewhat resemble those described by Cooke at the Francoeur property[1], Boischatel township, and at Larder Lake[2], Ontario.

(2) The second ore type is the ordinary quartz vein. Such veins range in size from minable widths down to hair-line cracks. Many of them are in bodies of silicified rock and may have acted as the channels through which silicification was effected; on the other hand, as they fill cracks in the silicified material, they may be the final deposits of the silicifying solutions, or they may be an entirely later deposition. One of the larger of these veins is found at No. 1 shaft of the East Malartic mine. It is about 4 feet wide, fills a sheared zone in quartz syenite porphyry, and its walls are silicified and pyritized. The vein material is white quartz carrying minor quantities of pyrite, galena, chalcopyrite, and native gold.

(3) A third and very important ore type is silicified and pyritized country rock, commonly either greywacke or porphyry. The silicified rock is fine grained or cherty, and light in colour—grey, yellowish grey, or white. It is cut by glassy quartz veins that grade to pegmatitic mixtures of quartz, albite, and mica. Neither the degree of silicification nor the abundance of pyrite, which is the most abundant sulphide, is an indicator of the gold content, for much highly silicified rock is not ore, and some parts poor in pyrite are richer than others containing much pyrite. In fact, there are places, as in the Sladen Malartic mine, where the ore is not at all silicified and is only moderately pyritic, so that it does not differ appreciably in appearance from barren porphyry or grey-

[1] Geol. Surv., Canada, Sum. Rept. 1925, pt. C, p. 34.
[2] Ibid., 1923, pt. C I, p. 67.

wacke. Besides native gold, which is rarely visible, these ores contain small amounts of galena, sphalerite, and at least two tellurides, sylvanite and, possibly, petzite. The siliceous replacements are best exemplified in the Canadian Malartic and Sladen Malartic mines.

(4) The fourth ore type is found mainly within the belts of chloritic schist that constitute the Cadillac "Break". Within these shear zones there occur discontinuous, lenticular sheets, ranging in width from nearly nothing to 15 or 20 feet and in length up to several hundred feet, of a dark, hard, massive rock of medium grain, generally termed 'diorite' by the operators. These bodies dip steeply to vertical. The operators view these masses as altered dykes, but this seems doubtful in view of their discontinuity and the fact that they seem to grade in places into the surrounding chlorite schist. In composition and texture they are unlike an intrusive rock. The writers have not seen sufficient exposures to offer any definite alternative explanation. It seems possible, however, that at least some of this 'diorite' may have been formed by the hydrothermal alteration of schist or tuff.

The 'diorite' bodies are cut by numerous small quartz veins that carry native gold. All the polished sections of this ore examined by the writers showed the gold confined to such veinlets; but the operators state that there also seems to be, in places, a rough proportionality between the gold values and the amount of pyrite. Values in the 'diorite' are found only in the parts within the shear zones; if the 'diorite' runs out of the sheared zones, the values disappear even though all the pyrite does not.

The tenor of the 'diorite' ranges from nil to about $15 a ton, and $8 may be an average figure. Ore of this type is found at the No. 2 and No. 3 shafts of the East Malartic mine.

(5) The fifth type of ore is the ordinary dark chlorite schist of the Cadillac "Break". In places this schist carries free gold, without quartz, as flakes between the leaves of schist, or occasionally in small nuggets and veinlets. Such places, of course, are not common, but their occasional presence adds greatly to the requirements for sampling and assaying, as they are commonly quite rich when found.

The many types of ore are probably due merely to differences in the country rock encountered by the ore-bearing solutions, and are not products of different periods of mineralization. It is common to find, in the mines, two or more of the above types of ore in the same ore-body. In one stope of the East Malartic mine all five occur, forming a single body of ore. The average grade of all the types, except the pegmatitic quartz veins, is between $5 and $10 a ton.

OTHER TYPES OF DEPOSITS

Rusty weathering, carbonatized zones in volcanic rocks have been found at a number of places. The best examples are at the Thompson Malartic (Dunlop Consolidated), Malrobic, and Panamint properties, in ranges V and VI, Malartic township. At a few places across widths that range from a few feet up to about 200 feet the chloritic greenstone at the north side of the north limb of the Blake River group is replaced by

ferruginous carbonate and carries small proportions of pyrite, pyrrhotite, and chalcopyrite. In places the carbonate rock is cut by quartz veins, some of which contain gold. Except at Malrobic the carbonate horizon is drift covered between Panamint and Thompson Malartic. It is also drift covered for considerable distances to the northwest and southeast. Developments in the past, including underground work at Malrobic, and considerable diamond drilling, have failed to prove any commercial deposits. Nevertheless, if carbonatization continues, as it well may, between and beyond the three properties this would be one of the most continuous and best defined zones of mineralization in the area.

Similar carbonatized greenstone, with abundant chromiferous mica, occurs near the north side of the Cadillac belt on the Demara group in Fournière township, and has been cut in drill holes at East Malartic mines farther southeast. Much the same is a carbonatized zone, on Valco ground, at the south contact of granite on lots 43 and 44, range V, Malartic township.

Massive to disseminated pyritic replacements, not known to carry appreciable amounts of gold, occur in the Malartic group at Malartic Lakeshore and on the west shore of Malartic Lake in lot 23, range VII, Malartic township. At the latter place the sulphides replace volcanic rocks alongside the contact of granodiorite. Pyrrhotite, chalcopyrite, and tourmaline are present in small amount, and calcite is fairly abundant.

Gold has been found in carbonatized and albitized chlorite schist of the Cadillac belt at Pan-Canadian. Pyrite, pyrrhotite, chalcopyrite, arsenopyrite, and tourmaline are present and magnetite is relatively abundant.

Of interest, but of no established value, are many veins and irregular masses of white " bull " quartz in granitic intrusives. They occur at Malrobic, the eastern Valco property, at the old Cartier Malartic, now held by Amphi Syndicate, and quite commonly in intrusives in the southwestern part of Malartic township and in Fournière township. From some of these gold has been obtained, but not in important amounts. Pyrite is the principal associated sulphide and the deposits would seem to be of pegmatitic origin, though not true pegmatites. They are not unlike the old Lucky Tiger deposit southeast of Canadian Malartic, where the orebodies were found to be very limited in extent.[1]

Recently some gold has been found by Celta Development and Mining Company, in pyritized granite in range IV, Malartic township. Quartz veins cut the granite and may contain most of the gold.

Small quantities of talc and asbestos occur in some of the serpentine dykes in the Malartic volcanics in the northern part of the area.

DISTRIBUTION AND STRUCTURAL CONTROL

Quartz veins and replacement deposits occur throughout the area, and it is doubtful if a single square mile can be found in which there is not at least one small auriferous deposit. However, outcrops are few, as the maps show, and even the areas mapped as outcrop are, many of them, timbered and moss-covered tracts with numerous scattered exposures.

[1] O'Neill, J. J.: Op. cit., p. 64.

Around some of the mines no rock at all is exposed, and the geology shown is inferred from subsurface developments. It will, therefore, be years before the possibilities of the district can be fully explored. Even the areas of outcrop may still repay careful prospecting. The discovery in 1936 of the rich Pan-Canadian vein under a cover, in places, of no more than an inch or two of moss and soil, in an easily accessible area of abundant outcrops that had been prospected by different people over a period of 10 years or more, is an excellent case in point.

The most important gold deposits as yet discovered in the area lie along or close to the Cadillac belt of greenstone, the southern limb of the Blake River group. This is also true in Cadillac township to the west of the area under discussion. At every property along the belt, intense shearing similar to that of the Cadillac "Break" has been encountered, and presumably is continuous through the unexplored, drift-covered areas between the proved occurrences. The properties along the greenstone belt are: Lapa Cadillac, Dunlop Consolidated (Mayrand option), Maritime Cadillac, Pan-Canadian, Partanen Malartic, East Malartic, Rand Malartic, and Malartic Goldfields. The Canadian Malartic and Sladen Malartic deposits lie just south of the belt, and are undoubtedly related to it structurally.

It is obvious that the mere presence of a belt of greenstone is inadequate to explain this distribution. Greenstone is a common rock of the region, but is not a host for ore except where other factors enter. The other principal feature of the belt, the intense shearing, thereupon presents itself as a possible cause of ore localization. The shearing was presumably caused by major faulting, and is so extensive horizontally that it must likewise have extended to great depth. The shear zone, with its subsidiary fractures, could, therefore, have acted as a channel for ore-bearing solutions. That it actually did act as a channel for fluids coming from great depths is proved by the concentration in and near it of numerous small masses of igneous rock of various types. Ore-bearing solutions could certainly have moved through it just as easily as fluid magma; and the intimate areal relation between the zone of shearing and the deposits is strong evidence that they did.

West of Lapa Cadillac mine the arsenical gold deposits of Cadillac township are distributed lineally along and near the Cadillac "Break." This pronounced shear zone is believed to have acted as the major structural control in the localization of the ores. Southeast of Lapa Cadillac similar deposits have been found along the Cadillac belt as far as Pan-Canadian mine. In this region, however, they also spread eastward and southeastward along and across the sediments of the Cadillac group, and into the northern limbs of the Blake River and Kewagama groups in the extreme eastern part of the area. Examples are deposits at the Deane-Cadillac, Valco Cadillac, Dempsey Cadillac, Lartic, and old Grover Daly properties, and in lots 34 and 35, range II, and lots 46 and 47, range I, Malartic township. Deposits of the Cadillac type, therefore, occur from the southern limb of the major syncline in Cadillac township to the northern limb in southeastern Malartic township. This distribution suggests that from Lapa Cadillac to Pan-Canadian mine the major struc-

tural control by the shear zone along the Cadillac belt persists. The eastward spread of the arsenical deposits across the Cadillac group may be explained by the fact that in this area the strata bend sharply south, but regional fracturing and schistosity strike east to south of east across the strike of the beds in the Cadillac group. Many of the veins follow cross-cutting fissures, and the Pan-Canadian high grade vein serves as a good example. Consequently, structures are available that facilitated the ascent of mineralizing solutions in the sedimentary rocks, deflecting them away from the Cadillac shear.

Southeast of Pan-Canadian the known deposits are all of the Fournière type. They occur only along and south of the southern limb of the Blake River group (Cadillac belt), and at each property in the belt one or more zones of intense shearing has been proved to exist. Furthermore, at each property, the Pan-Canadian No. 1 showing, at Partanen Malartic, East Malartic, Rand Malartic, and Malartic Goldfields, there are acidic porphyry intrusions, quite unlike the albitite and quartz albitite of Cadillac township, in the sheared volcanic rocks. Therefore, there is good reason to believe that the intense shearing has acted as structural control for the ascent of intrusives and mineralizing solutions. So far as is known no similar mineral deposits occur north of the greenstone belt, though it must be remembered that this part of the area is very largely drift covered. However, besides the very apparent distribution of the ores along the Cadillac belt, there is a distinct westerly trend away from it. The Sladen Malartic and Canadian Malartic deposits, within the Kewagama group, exemplify this. The deposits in these two mines lie along an east-west zone near the south contact of a large body of quartz syenite porphyry. Already sufficient evidence has been obtained to suggest strongly that a zone of brecciation and faulting extends across the properties from the south side of the Blake River group near the Sladen-East Malartic boundary, and that this westerly trending zone has a definite bearing on the localization of the ores. It may be a subsidiary fault zone from the Cadillac "Break." Its junction with the "Break" is probably near the east side of Sladen Malartic property, where diamond drilling has shown pronounced drag-folding, or complicated faulting, of the sheared contact zone of the Blake River and Kewagama groups. The distribution of the Fournière type of deposits, therefore, is indicative of structural control of mineralizing solutions by faulting and shearing along the Cadillac belt, and by accessory, possibly subsidiary, faulting trending west from the belt into the Kewagama group. Of importance also may be the rather complex structure of the Kewagama sediments in the zone of S-shaped drag-folds that extends northwest-southeast through Canadian Malartic ground. At least some of the porphyry intrusions are conformable with the structures in the sediments. The deposits in Canadian Malartic and Sladen Malartic mines are chiefly large siliceous and pyritic replacements in greywacke and porphyry. The easterly trending zone in which these deposits lie has been traced eastward almost to the East Malartic boundary. There it encounters the southeasterly trending sheared zone at the south side of the Blake River group, and the trend of the mineralized zone swings to the southeast with the sheared zone. Siliceous replacements continue along

the south side of the shear zone, in the northern edge of the Kewagama greywacke. But the chloritic schists to the north were not susceptible to silicification, and the gold there is in pyritic, quartz-veined bodies of dioritic rock in mineralized porphyry dykes, and in the schists themselves. The change in the character of the deposits is undoubtedly due to the nature of the host rock rather than to variation in the type of mineralizing solutions.

As already noted, there is a well-defined zone of carbonate mineralization in Malartic township along the north side of the northerly band of the Blake River group. The Thompson Malartic, Malrobic, and Panamint properties are on it. No deposits of commercial value have as yet been found, but much of the carbonatized horizon is drift covered and unexplored. Discouraging results have been obtained in the development of quartz veins and sulphide replacements in the westerly continuation of the same belt of volcanic rocks across Cadillac township, but no very extensive exploration has been carried out.

On the whole the rocks of the Malartic group are relatively massive and competent, not particularly favourable to the occurrence of ore deposits, and no very persistent lineal structures were found in them. The Central Malartic vein occupies a fissure where the strata bend sharply south in the most important major flexure in the group. Veins on and near the Malartic Lakeshore property are in an area surrounding another abrupt flexure well within the group. The most pronounced shear zone in the volcanic rocks is along the south contact of the intrusive body on Valco Cadillac ground, lots 43 and 44, range V, Malartic township.

Sulphide replacements and siliceous deposits, some of them reported to contain gold, have been found along the south contact of the Malartic Lake granodiorite and in the volcanic rocks to the south. The intense brecciation and shearing of this intrusive has been dealt with on a preceding page.

Unfortunately the data are so meagre that very little can be said of the economic possibilities of the Little Heva River drag-fold and the area east of it in the southern part of range IV, and the northern half of range III, Malartic township. The structure itself is intriguing and some gold has been found in and near granitic intrusives in range IV, between the highway and Malartic River. The structure around and east of the river, in range III, is known to be complicated by faults and drag-folds, but has not been satisfactory solved.

Of much importance to developments beyond the area, is the fact that the Cadillac belt trends eastward from Malartic Goldfields into Dubuisson township. The area along its probable continuation, at least as far as Thompson River, should be of considerable economic interest.

ORIGIN OF THE GOLD DEPOSITS

The origin of the Cadillac type of ore has been discussed at some length in Memoir 206. It was there shown that these deposits are closely associated in space with intrusions of albitite and quartz albitite; also that some albitites are rich in tourmaline, a characteristic vein mineral, and that many veins contain some albite. In fact, there seems to be a gradation in composition between albitites and veins. From these facts it was concluded that both the veins and the albitites are probably emanations from

a common magma. Little additional evidence was found in the area now under consideration, so that no reason exists for modifying the above conclusions.

The origin of the Fournière type of ore was undoubtedly different, as these ore-bodies not only differ mineralogically but, as will be shown, the gold recovered contains much more silver than does the gold of the Cadillac type. The ores of the Fournière type are associated with albite granites, quartz syenite porphyries, and similar intrusives, which are not found where the Cadillac type appears. Although these intrusives are cut and silicified by the veins, and are, therefore, definitely older, the age difference was probably small. The source of the auriferous pegmatites was in all probability the quartz syenite porphyry. Mining operations on the Canadian Malartic property have shown them to be abundant within the porphyry body there; and if they did not carry gold, no one would doubt the genetic relationship. Most acid intrusives of the Canadian Shield are accompanied by pegmatites that represent the final products of magmatic differentiation; and the mere fact that these pegmatites carry gold is no reason for doubting their relation to the intrusive with which they are closely associated. This conclusion, of course, implies that the gold of the pegmatites was derived from the quartz syenite porphyry magma. It does not, however, imply that all the silicified rocks carrying low gold values were altered and enriched by solutions emanating from the porphyries. Although such may have been the case, no data have as yet been obtained to prove it. However, some of the better ore-bodies seem to be in places where the low-grade silicified materials have been "sweetened" by the presence of richer pegmatite veins. It is, therefore, probably a matter of much importance that similar porphyry intrusions have been found in abundance by drilling along the belt eastward into Dubuisson township, at least as far as Thompson River; and also along and south of the Cadillac belt northwest of Canadian Malartic. Much of this part of the belt, being heavily drift covered, is still unexplored.

It has been found that the Cadillac type of ore yields a bullion much richer in gold and poorer in silver than the Fournière type; a fact affording some support for the conclusion that the two originated from different sources. The following are the available figures, for which the writer is indebted to the executives of the different mines.

Mine	Period	Proportion of gold and silver	
		Au	Ag
Thompson Cadillac	Jan. 1, 1938, to Jan. 1, 1939	920	80
O'Brien Gold	Oct. 3, 1937, to Oct. 1, 1938	904	96
Lapa Cadillac	Five bricks	953	47
Pan-Canadian	From $37,391.62	910·5	89·5
Sladen Malartic	Six bricks	272	728
East Malartic	First production, approximate	828	172
Canadian Malartic	May 1, 1935, to May 1, 1937	655	345
	Jan. 1, 1938, to Dec. 1, 1938	703	297

At the first four properties arsenopyrite ores are mined, and the figures show a consistent high proportion of gold. Some allowance should probably be made for differing methods of concentration; and the Lapa Cadillac deposits, yielding a bullion unusually rich in gold, are in part replacements in schist, whereas quartz veins yield most of the gold on the other properties. Bullion from the three mines in Fournière township not only contains much more silver, but the proportions are more variable. Sladen Malartic bullion is remarkably high in silver, perhaps because the ores contain tellurides and considerable galena. The East Malartic ores differ greatly from those at Sladen Malartic and Canadian Malartic, and, if one may judge from approximate first figures, carry a much higher proportion of gold. The Canadian Malartic figures are interesting, as the proportion of gold increased in 1938 by about 5 per cent. It was in this period that ore from the pegmatitic veins in porphyry was first brought to the mill, and it formed about 5 per cent of the total milled. This new ore seems to contain more gold and less silver than the larger siliceous replacement bodies. E. V. Neelands has informed the writer that a limited number of assays of the new ore indicate the proportion of gold to silver to be 86·2 to 13·8.

CHAPTER III

DESCRIPTIONS OF PROPERTIES

AMPHI GOLD SYNDICATE

Amphi Gold Syndicate has large holdings in Malartic township. As reported in March 1937, by T. W. McDowell, President of the company, there are ten groups, embracing the following lots: 7 to 12, 40 to 48, and the south halves of 2 to 6 and 60 to 64, in range III; in range II, lots 1 to 7, 38 to 49, 62 to 64, the north halves of lots 8 to 11 and lot 50 and the south halves of 36 and 37; in range I, lots 1 to 9, 16 to 44, 52 to 56, 63 to 64, and the north half of lot 62.

Up to the autumn of 1936 the syndicate had done little but preliminary work except on the north halves of lots 8 and 9, range II, where they did some diamond drilling on the south side of the Cadillac belt to explore a section of low ground. Porphyry dykes and some quartz had previously been found in trenches along the southwest side of this low ground. It is reported that no great encouragement was obtained. In 1935 the syndicate did some drilling at the south side of the Cadillac belt on lot 1, range III, ground that was developed later by Dempsey-Cadillac Gold Mines. Later in 1936, Mr. McDowell reports, some interesting quartz veins were discovered on lots 41 to 43, range III. In 1937 the company's holdings south and east of Partanen Malartic were optioned by McIntyre Porcupine Mines, and those northwest of Partanen were being developed by International Mining Corporation.

A large percentage of the syndicate ground is heavily drift-covered. As the map shows, examples of practically all the rock types of the area occur somewhere on the holdings. The Cadillac belt runs through lots in the western parts of ranges I, II, and III. Developments at adjoining properties such as Pan-Canadian, Partanen Malartic, and the western part of Sladen Malartic's Fournière township property should be of significance for any plan of exploration that is formulated for this part of the syndicate's property. The probability that a major shear zone extends across this part of the area along the southern side of the Cadillac belt has been emphasized elsewhere in the report.

The old Cartier Malartic mine, now held by Amphi Gold Syndicate, is in the southern part of lots 16 and 17, range I. Laurentian Gold Mines, Limited, held the ground from 1923 to 1927 and did preliminary work on a large surface showing of white quartz. In 1928 Cartier Malartic Gold Mines sank a shaft on it to 105 feet and did over 100 feet of lateral work from the bottom. Operations were discontinued that year, after some additional trenching and diamond drilling had been done.

The geology about the deposit is most interesting. Greywacke of the Kewagama group is intruded by one major body and many smaller dykes of grey to brown, fine- to medium-grained albite granite. This rock consists of about 50 per cent albite (An_3), 20 per cent quartz, 10 to 15 per

cent microcline, and minor amounts of various ferromagnesium minerals. The plan of the major body at the surface is roughly S-shaped, with the two ends trending southeast and northwest, respectively, the middle part northeast. Dykes run off from the middle part easterly (*See* Figure 7). Its greatest width at the surface is about 450 feet. The outlines of the body conform to the general structure of the surrounding greywackes, which are bent in a large drag-fold. As the general map shows, this drag-folded zone extends south 30 degrees east for at least several thousand feet from the shaft, and may continue west of north as far as the Cadillac belt at Partanen Malartic. Because the albite granite is neither sheared nor crushed, even at the contact, and because the contact was observed, in a few places, to cut sharply across folded beds of greywacke, the writers conclude that the injection took place after the drag-folding, and that the structure controlled the form of the intrusive. The sedimentary rocks around the northern part of the main mass dip 60 to 80 degrees east and northeast; the intrusive body may have a similar dip.

The main body of albite granite and many of the subsidiary dykes are jointed and traversed by many veins of white to vitreous, moderately coarse-grained quartz. Many of the veins, a few inches to a foot or two across, strike about at right angles to the adjoining contact of the intrusive and dip gently to steeply east or northeast. There are also irregular bodies and pockets of quartz with no well-defined attitude. Most of the quartz is remarkably barren of sulphides. Pyrite is the most abundant, but is much more abundant in the granite than in the quartz. Small amounts of galena and chalcopyrite were noted in a few places. A few veins also contain small amounts of ankerite and tourmaline. Small seams and flakes of chlorite, biotite, and muscovite were the only other constituents noted.

The shaft, now flooded, is near the middle of the northernmost hook of the main intrusive body. There irregular veins and masses of white quartz form 50 to 100 per cent of exposures covering hundreds of square feet. The writers have no knowledge of values obtained. The old buildings and equipment are in bad repair, and apparently no work has been done since 1928.

Group ten of the syndicate is lots 40 to 48, range III. When these claims were examined in September 1936, the only developments were a few old strippings and trenches mostly caved and filled with water. The western part of this group is underlain by fragmental volcanic rocks ranging from fine-grained tuffs to coarse, angular breccias. These, in lot 42, are underlain successively to the north by 50 feet of rhyolite with interbedded rhyolite tuff and clastic material, 80 to 100 feet of agglomerate, 50 feet of coarsely crystalline gabbro, and 50 feet of clastic sedimentary rocks; these last lie upon a thick series of massive and pillowed flows of andesite and dacite.

The beds near the main showing, in the middle of lot 42, are poorly exposed, but appear to be bent into a sharp, Z-shaped drag-fold. The axis of the drag-fold strikes 13 degrees north of east. A small fault exposed on the east side of the fold strikes 25 degrees north of east and may offset the inner limb of the fold a few feet.

The main showing is a pyrite-bearing quartz vein, exposed in a trench 200 feet long. The vein strikes about 10 degrees north of east, dips

vertically, and lies within the southeastern bed of the drag-fold, in a shear zone 10 feet wide that cuts across the contact of the 50-foot sedimentary bed against the volcanic rocks. The vein is up to 4 feet wide. The east end has not been located unless it was found in a series of pits and trenches to the eastward, which are now water filled. Near the west end of the main trench the vein pinches, but 10 feet west a second vein begins and where the trench ends, 30 feet farther west, it is 3 feet wide.

The quartz in the vein is milky to vitreous and carries little if any sulphides; the wall-rock, however, is charged with finely divided pyrite, biotite, and a little tourmaline. No information as to gold content was obtained.

The work by McIntyre Porcupine Mines, Limited, in 1937 and 1938 was done in lots 16 to 29, range I. Maps supplied by the company show that the south contact of the Blake River group was drilled at wide intervals for 5,000 feet southeast from the range II line at lot 15. In this distance a broad zone of talcose chlorite schist lies 100 to 1,100 feet northeast of the contact, and bodies of diorite and albite granite or quartz syenite were intersected south of the shear in greenstone. Several closely spaced holes were drilled on lot 20; and some gold was obtained at the south side of the shear zone, where greenstone and schist are intruded by granite and diorite. At least one drill hole was put down under the highway at the south end of lot 28 to probe the body of porphyritic granite there. The option on the property was dropped late in 1938.

International Mining Corporation did surface exploration along the Blake River group northwest of the Partanen Malartic property late in 1937. The writers have no knowledge of the results obtained, but the option was dropped.

BAYSIDE MALARTIC MINES, LIMITED

Bayside Malartic Mines, Limited, controls lots 44 and 45, range V, Malartic township, and four claims to the north on Malartic Lake. The company is sponsored by Mining Enterprises, Limited, the previous owner. A small amount of surface work had been done by Mining Enterprises when the property was examined in September 1936. Some diamond drilling was done by Bayside Malartic early in 1937.

Presumably, the whole property is underlain by Malartic volcanic rocks and intrusive rocks, but except along the lake-shore there are very few outcrops. On the shore the volcanic rocks are cut by numerous dykes of granite, aplite, and lamprophyre. Part of the Malartic Lake granodiorite body is exposed on islands to the north.

Two small showings are exposed by trenches and pits on the narrow point on lot 44. One of these, on the northwest corner of the point, consists of a network of crooked quartz lenses in sheared andesite. The shearing strikes north 60 degrees west and dips 80 degrees south. The quartz is accompanied by tourmaline, a little pyrite, and much calcite. Erratic gold values were reported. The second showing is 350 feet south. A zone, 10 inches to 5·2 feet wide, of highly silicified, sheared andesite has been followed for 280 feet along the south shore of the point. Its strike is

north 65 degrees west and the greatest width is at the east end. The fine-grained, cherty, silicified rock weathers milk-white. Many dark, unreplaced remnants of greenstone give it a striking, banded appearance.

The albite granite of the Valco property extends eastward on to lot 44, as does the highly carbonated zone at its south side. In the southeast corner of the same lot there are limited exposures of volcanic rocks, cut by many acidic dykes. Small veins of quartz and tourmaline occur in a dyke of feldspar porphyry at the north edge of these outcrops.

CANADIAN MALARTIC GOLD MINES, LIMITED

References: Cooke, H. C., James, W. F., and Mawdsley, J. B.: Geol. Surv., Canada, Mem. 166, p. 278 (1931).
O'Neill, J. J.: "The Canadian Malartic Gold Mine, Abitibi County"; Que. Bur. Mines, Ann. Rept. 1934, pt. B, pp. 61-84.

The Canadian Malartic mine has been operated since May 1935. On February 1, 1937, a new mill, capable of treating about 700 tons a day, was put in operation. This is the second increase from the original 150-ton installation. The 1937 annual report of the company gives the following information:

Tons of ore milled	232,326
Average a day, tons	636·5
Metal sales (gross value):	
Gold 29,798·265 ounces Silver 14,172·53 ounces	$1,048,570.74
Metal sales per ton of ore milled	4·51
Total operating costs	$597,699.22
Operating cost per ton of ore milled	$2.57
Operating profit (after providing for depreciation, etc.)	$436,683.46
Operating profit per ton of ore milled	$1.88
Net profit for the year	$198,661.20

—	Tons	Average grade a ton	Value (gold at $35)
		Ounces	$
Assured ore reserves	398,000	0·173	6.05
Indicated ore reserves	486,000	0·141	4.93

The recovery of gold averaged 88·4 per cent in 1937. Deductions from the operating profit included $84,425.60 for depreciation and $116,163 for deferred development, the latter charged at 50 cents a ton of ore milled. In the ore reserves "no addition has been made for ore indicated by drifting and diamond drilling to the east, as information is too limited to permit estimates".

The mine (*See* Plate IV) is in Fournière township, on the main highway and one mile south of Malartic township. E. V. Neelands is general manager and J. P. Millenbach is general superintendent.

J. J. O'Neill examined the mine in great detail in 1934 and his report was published late in 1935. The writers, therefore, made no attempt at a comprehensive examination of the property. Instead, the surface geology around the mine was carefully mapped, with a view to obtaining as much information as possible on structure and its relation to the ore deposits (*See* Figure 2). Parts of 3 days were spent underground with the sole purpose of obtaining a general knowledge of the type of mineralization and the geological setting of the ore-bodies, so that a brief statement could be included in this report. To this end H. C. Hertz and D. R. Derry of the company have rendered generous assistance.

The principal ore-bodies are large, siliceous replacements in greywacke of the Kewagama group. The greywacke is intruded by a few dykes of diorite and by later dykes and large masses of quartz syenite porphyry, and, in places, the porphyry is silicified and mineralized like the greywacke. Fine-grained pyrite is the chief sulphide; it is disseminated in the silicified zones and also in the adjoining, unsilicified rocks. No consistent relation has been found to exist between the amount of pyrite and gold content of the ores. Other metallic minerals, present in small amount, are chalcopyrite, sphalerite, and galena. Gold occurs as native metal, generally so finely divided as to be invisible to the naked eye, but occasionally in distinguishable particles. Ore varies from pyritic, slightly silicified, micaceous greywacke to completely silicified rock that is grey to yellowish and cherty or sugary white. The pyrite content is variable, up to about 3 per cent.

Widespread silicification was the first step in mineralization. Later, the wide, silicified zones were fractured and quartz veins were deposited along the fractures, causing some further silicification. The vein quartz is coarsely crystalline and glassy to white, and associated with it are small amounts of tourmaline, muscovite, and feldspar. Indeed, there is a gradation in places from veins of nearly pure quartz to veins of feldspar, quartz, and mica that are definitely pegmatites. Pyrite and native gold and minor quantities of the sulphide named above accompany the veins.

The ore-bodies occur in wide, silicified zones that follow lines of shearing and brecciation. The north zone strikes nearly due west, approximately parallel to the strike of the strata, and has been traced by drill holes and mine workings for 3,500 feet from the east boundary of the property. For 1,500 feet from the boundary it borders the south side of a boss of porphyry; west of that, within 300 feet of the surface, there are narrow dykes of porphyry along it. To a depth of about 400 feet the dip is nearly vertical; below that it dips to the south above and parallel to the porphyry contact. At the west end the north zone terminates against the south zone, which strikes southeast from it for 600 feet, where it joins a broad zone of silicification lying around the east end and south side of a small boss of porphyry. The south zone dips easterly, the angle decreasing from 60 degrees at the surface to about 45 degrees below the 250-foot horizon. The trough-like junction of the two zones plunges southeast. Porphyry dykes follow the hanging-wall side of the south zone. The ore-bodies developed in the upper three levels of the mine are practically continuous from the southeast end of the south zone to the junction with the north zone and for 850 feet east along that zone.

Diamond drilling and some underground work have indicated additional ore in the north zone at intervals to the Sladen Malartic boundary. A northerly rake of the ore in the south zone and the southeasterly pitch of the junction of the two zones shorten the stope lengths in the south zone to about 150 feet at the third level. Stope widths vary from 30 to 70 feet and the boundaries of the ore can be determined only by careful sampling. Most of the ore to date has been extracted from the south zone above the third level.

Early workers have diagnosed the silicified zones as replacements along an S-shaped drag-fold in the greywacke. O'Neill, however, states that the easterly strike of the greywacke remains practically constant throughout the mine. The north zone approximately follows the bedding of the greywacke and the south zone, therefore, should cut sharply across the strike if the strata are not folded. The destruction of bedding planes by intense silicification in the mineralized zone makes it impossible to get as many structural observations as might be desired. The writers could find no proof in the upper mine workings that the south zone follows the bedding; all observations obtained show the bedding planes striking into the silicified zone at angles near 45 degrees. At the surface, however, there definitely is a sharp, S-shaped drag-fold at the southeast end of the south zone (*See* Figure 2). To the northwest the rocks along the silicified zone have been sheared and brecciated. In other words, the drag-fold does not seem to have controlled the localization of silicification except perhaps at the extreme southeast end of the south zone.

Since O'Neill examined the property the principal development has been the establishment of the fourth, fifth, and sixth levels, the latter 750 feet below the surface. Crosscuts were driven south to connect No. 2 inclined shaft on the south zone with the vertical No. 1 shaft, which at the surface is north of the north zone and some 500 feet east of its west end. To the third level narrow dykes of porphyry were encountered north of the north zone, but at the fourth level greater thicknesses of porphyry were cut in a crosscut just south of the shaft, and porphyry in increasing amounts was found downwards, until at the sixth level the south crosscut is in porphyry for over 200 feet. These facts, and some deep drill holes, show that the porphyry body, which at the surface lies some distance east of the shaft, enlarges at depth, and not far below the sixth level completely underlies the present mine workings. No large siliceous ore-bodies like those in the overlying greywacke have yet been found in the porphyry.

Of great interest is the discovery of pegmatitic veins and irregular bodies of auriferous quartz in the porphyry. The first occurrence of this kind was found on the sixth level 100 feet south of No. 1 shaft. At that place development disclosed a body 10 by 80 feet estimated to contain three to four times as much gold as the mine average. The ore is in a fracture zone striking northwest in porphyry, and consists of irregular veins of coarse white to watery quartz, which trend northwest. The adjoining, normally grey porphyry is altered to pink or brown. Associated with the quartz are biotite, muscovite, chlorite, pyrite, chalcopyrite, purple fluorite, black rutile, tourmaline, and a little garnet. Since this body was discovered in 1936 other similar bodies have been found to the east on the three bottom levels, and the list of associated minerals has grown to include

molybdenite, scheelite, and specularite. Pink albite is intergrown with quartz in some places, and native gold is visible, generally as small particles, in several places in the quartz. The deposits are definitely pegmatitic and vary in size and nature from the large irregular body on the sixth level to narrow, well-defined veins and zones of small veins. Some 5 per cent or more of the mill feed is now being obtained from them, with a consequent increase in the average grade of ore.

In 1938 plans were being made to sink a shaft near the east end of the property to assist in development of the auriferous bodies that have been indicated by drilling for about 1,500 feet between the present mine workings and the east boundary. The indications have been obtained at and south of the south contact of the large body of porphyry that is exposed at the surface on this part of the claims. The west ore-body of Sladen Malartic mine has been stoped to the Canadian Malartic boundary.

CELTA DEVELOPMENT AND MINING COMPANY, LIMITED

This company holds lots 29 to 35, range IV, lots 31 to 39, range III, and lots 33, 35, and the north halves of 36 and 37, range II, Malartic township. Surface development was started in September 1936 and continued through 1937. About one dozen diamond drill holes were put down after much trenching had been done. Most of the work is in lots 31 to 35, range IV. The writer is indebted to the manager, Th. Koulomzine, for data on the developments; in 1937 a brief visit was made to the property.

The property is a large one and is underlain by strata of the Malartic, Kewagama, Blake River, and Cadillac groups, and by several intrusive bodies. Principal interest attaches to the range IV holdings, where most of the development work has been done. The northeastern part of this area is underlain by steeply dipping, andesitic to rhyolitic lava flows, siliceous tuffs, and agglomerates of the Malartic group. The strata strike about north 60 degrees west. They are intruded by a few feldspar porphyry dykes and by bodies of diorite and gabbro. To the southwest are overlying beds of greywacke of the Kewagama group, well exposed in lot 32 on the line between ranges III and IV. The contact between the two groups is not exposed, but judged by exposures in range III and in trenches in range IV it would appear that near the contact there is an interbedding of agglomerate, tuff, and greywacke. In 1936 a few outcrops of granite were found in the course of ordinary geological mapping. They are in two areas, 2,000 feet apart, in range IV. Those on the west, in lots 31 and 32, are of a greenish grey, buff to pale grey weathering albite granite, even grained to porphyritic. It consists of about 55 per cent albite (An_3), 15 per cent microcline, and 20 per cent quartz. The feldspar is sericitized and cut by veinlets of ankerite. The maximum grain size is about ⅛ inch and the rock is cut by small veins of watery quartz. The exposures to the southeast, in lot 34, are more highly feldspathic and weather brown, due to a large proportion of pyrite and ferruginous carbonate. A large grab sample, containing about 2 per cent pyrite but no quartz stringers, was assayed by the Bureau of Mines, Ottawa, and carried 0·06 ounce silver and 0·16 ounce gold a ton. The attention of Mr. Koulomzine was called to the locality in

September 1936. Development work done since then has shown that there are two distinct bodies of granite. The westerly one is more than 1,200 feet from north to south, and probably does not extend eastward into lot 33. The easterly one is about 800 feet in diameter and its west end is in lot 34. The western body apparently straddles the contact between the Malartic and Kewagama groups, for it intrudes greywacke on the south and is bordered on the north and east by volcanic rocks, though the actual contact there is not exposed. Between the two intrusive bodies, and around the west end of the eastern one, the company has partly exposed, and drilled, a northwesterly trending zone in which lavas, tuffs, agglomerates, and some green feldspar porphyry are sheared and intruded by dykes of granite.

Mr. Koulomzine reports that interesting, but erratic, gold values have been proved at intervals along the sheared zone between the two bodies of granite, and that visible gold was found in two places in one drill hole. Erratic values have also been found in the eastern granite near where the writers took their grab sample. Quartz veins in both bodies of granite are in places auriferous. These veins are a few inches to 3 feet wide, and molybdenite and some columbite have been found in them.

Development has not been carried far enough to prove the value of the deposits. Particular interest attaches to the discoveries because they lie in the northern part of the area where there has been much less mining development than to the south, and where results in the past have been rather discouraging.

The remainder of the large property is largely drift covered. Attention may be called to the fact that the company owns lots 33 and 35, range II, and that an arsenopyrite-bearing vein of the Cadillac type occurs in greenstone of the Blake River group in lot 34, near the side of lot 35. Also, there is some evidence of a major fault or shear zone at that place.

CENTRAL MALARTIC GOLD MINES, LIMITED

This property is reported to consist of about 400 acres, comprising lots 13 to 16, inclusive, range VI, Malartic township. The company did some surface work in 1934, but fell into financial difficulties in 1935. The property was optioned in 1936 by Malrobic Mines; additional surface work was done and several diamond drill holes put down on the north half of lot 13, range VI, east of Heva River.

The property is underlain by lavas and pyroclastics of the Malartic group on the northeast and by sedimentary rocks of the Kewagama group on the southwest. The sedimentary rocks are exposed in only a few places, and consist of greywacke, with some conglomerate along the contact with the volcanic rocks. The strike of the contact apparently swings from nearly due north at the northwest corner of the group of claims, to northwest in the southeast part. The volcanic rocks include andesite, spherulitic and amygdaloidal rhyolite, dacite, and beds of tuff and agglomerate. Along flow contacts the rocks are impregnated with pyrite and locally sheared to zones a few feet wide that weather rusty brown. All the strata are intruded by a great many, small, even-grained to porphyritic, acidic dykes.

Near the workings there are many minor faults. Most of them strike northeast to east of north and have left hand offsets, but there are also a few that strike north of west and have right hand offsets.

Two principal veins have been developed on the property. They lie in the Malartic volcanics, about 250 feet east of the contact with the Kewagama group, but the contact is exposed only at one place, southwest of the southerly or No. 1 vein.

No. 1 vein is on a prominent knoll of volcanic rocks. It occupies a shear zone, up to 8 feet wide, that strikes north and along which has been intruded a small biotite lamprophyre dyke. The shear is later than and offsets slightly a porphyry dyke that crosses it, the east wall having moved 10 feet north relative to the west. The vein and the shear have been traced for about 400 feet; the quartz is lenticular along the shear, and is not continuous, but pinches out completely in several places. The maximum width of quartz is about 3 feet, but stringers of quartz lie parallel to the vein for a distance up to 2 feet in either wall. Calcite and some pyrite accompany the quartz. In places the vein becomes a breccia due to inclusions of country rock.

No. 2 vein, from which the best assays in gold are reported, is 300 feet northwest of No. 1. It is exposed in trenches at the west edge of outcrops of andesitic lavas. In these trenches a lenticular quartz vein has been followed for a length of 400 feet. It is up to 2½ or 3 feet wide in a sheared zone that strikes 5 to 10 degrees east of north and dips vertically to steeply west. In the southern half the vein is really a silicified and pyritized shear zone, with quartz stringers and disseminated pyrite. On the north, where quartz is more abundant, the walls are silicified and pyritized for 2 or 3 feet from the central vein, giving widths up to 8 feet or so of well-mineralized material. In 1936 several drill holes were put down to probe the vein at shallow depth.

A different type of occurrence is exposed for 20 feet in trenches 350 feet east of No. 1 vein. It is a decidedly lenticular vein of coarsely crystalline quartz, pink feldspar, and calcite, in a sheared andesite. The quartz and feldspar are veined and spotted with pyrite and chalcopyrite. The width ranges from 3 to 10 inches. Minor northeasterly striking faults offset the veins a few inches.

DEANE-CADILLAC MINING CORPORATION

This corporation owns seven claims immediately south of the east-west centre lines of Cadillac and Malartic townships. Six claims are in Cadillac, one in Malartic. E. T. Deane and R. Ferguson of Amos held the property for a number of years and did considerable surface work prior to 1936, when the corporation was formed. During the autumn and winter of that year a dozen drill holes were put down. The transmission line of Northern Quebec Power Company crosses the northern part of the property and the new Montreal-Rouyn highway is one mile to the east.

The claims are underlain by strata of the Cadillac group that strike, on the average, north 65 degrees west to north 70 degrees west and dip almost vertically. The rocks are massive to moderately schistose, the schistosity trending parallel to the bedding or across it at angles up to

about 15 degrees. The principal exposures are in the northeast corner and the west central part of the property. Siliceous to argillaceous greywacke and mica schist are the most abundant rock types. In the southern half of the property several beds of conglomerate are interbedded with greywacke, and a 15-foot bed of green agglomerate is poorly exposed near the centre of the west boundary. For at least 500 feet north of this there are beds and discontinuous streaks of magnetite in the greywacke, some of which, with the adjoining sediments, are intricately drag-folded.

Only one intrusive body is known. It crosses the township line 1,600 feet south of the north boundary of the property, and is poorly exposed in Malartic township. The rock is dark grey, massive to slightly schistose, and on a weathered surface resembles siliceous greywacke. However, on a wet surface, tabular feldspar phenocrysts about 3 mm. in length become apparent. The phenocrysts are albite and are set in a fine-grained groundmass of quartz and feldspar, so that the rock may be termed albite porphyry. Fine-grained pyrite is disseminated throughout in variable amount.

Drilling has shown that the porphyry is a vertical sill, about 250 feet thick, that pinches out suddenly on the west in Cadillac township. The drilling has also shown that it intrudes a band of sheared green tuff and agglomerate, with some intercalated greywacke, that is not exposed on the property; about 200 feet of these volcanic rocks lie north of the intrusive. The tuffs are converted in part to amphibolite.

A number of small veinlets of quartz and carbonate cut the intrusive, and the drill cores show that the rock is in part silicified and bleached to a grey, dense, porcelaneous material that closely resembles the typical quartz albitite of Cadillac township. This is not surprising, as the two rocks are almost identical in composition.

Numerous faults of small displacement were noted. One set strikes within a few degrees of northeast, another north 20 degrees west to north 30 degrees west. The former are left hand faults, the latter right hand. The horizontal displacements are generally small, much less than the maximum of 40 feet observed on one northeast fault.

There are many small quartz veins, the majority barren of sulphides and probably of gold. Surface development has been limited to trenching the porphyry body and to stripping veins in two places.

The so-called River vein is on the south bank of Heva River 800 feet west of Malartic township. It is vertical and strikes north 75 degrees west, with the bedding of siliceous greywacke. In an exposed length of 70 feet the width ranges from an inch or less at the east end to about 3 feet. There are small quantities of pyrite, arsenopyrite, sphalerite, and chalcopyrite in the vein or the adjoining wall-rock, and grab samples are reported to have yielded up to $25 in gold a ton. However, no important amount of gold was obtained in five drill holes put down in 1936 to intersect the vein at depth, but low assays were encountered in quartz-veined conglomerate that lies not far north of the vein.

Other quartz veins have been trenched 1,000 feet north of the River vein, at the south edge of a rocky knoll of greywacke and magnetite beds. They carry small amounts of tourmaline, arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. The most persistent vein zone is about 10 feet

wide and 175 feet in length. Another, 800 feet to the west, consists of a vein zone some 6 feet wide and 70 feet long. Grab samples from both these occurrences are reported to have yielded interesting assays, but drilling in 1936 did not justify further development.

Several drill holes were put down to test the porphyry mass, and particularly to explore its northern contact under heavy drift. One hole, approximately beneath the township line, cut several small veins of bluish quartz near the contact and free gold was noted in several of them. Additional drilling failed to indicate an ore-body.

DEMARA GROUP

(Quebec Gold Mining Corporation)

(National Malartic)

The Demara group is reported to consist of nine unsurveyed claims, A40350 to A40353, and A42993 to A42997, in Fournière township, between Sladen Malartic and East Malartic mines. The highway crosses the southwest corner of the property. Quebec Gold Mining Corporation and Mr. L. K. Coffin and associates exercise joint control. In July and August 1934, the property was thoroughly prospected before a number of trenches were made in areas where bedrock could be reached. There was no activity in 1935 and 1936. Bedrock outcrops in only some half dozen places on the claims, the rest of the surface being deeply covered by clay and gravel.

So far as can be told from the very limited outcrops, the southern half of the property is underlain by the Cadillac belt and the northern by greywacke and conglomerate of the Cadillac group. The extreme southwestern corner is probably underlain by greywacke of the Kewagama group. The Cadillac belt may be about 2,500 feet wide, and presumably consists of highly altered lavas, tuffs, and perhaps some sedimentary rocks, cut, no doubt, by dykes of diorite and in part converted to serpentine. Massive serpentine is exposed on the south bank of Malartic River on claim A42996, in the southeastern corner of the property, and there are a few exposures of highly altered volcanic rocks, 1,200 feet to the northwest, on both sides of the river. In each place the volcanic rocks are intruded by dykes of feldspar porphyry. At the southeastern exposures, the serpentinized rocks are intruded by two sub-parallel dykes of albite prophyry, or by one that is about 70 feet wide, striking approximately north 20 degrees west. The rock is grey to pink, slightly porphyritic, and consists of small albite (An_2) phenocrysts in a groundmass of very fine-grained quartz and albite. Hornblende, pyrite, magnetite, carbonate, apatite, leucoxene, and rutile are accessories, hornblende the most abundant. Six feet of amphibolite was noted in the porphyry in one trench—it may be an inclusion or it may mean that there are two distinct dykes.

A number of deep trenches have been put down to the northeast, mostly on the north side of the river, but also on its west side where the river turns to flow south for a short distance. One-half the trenches are now badly caved. However, enough can be seen to prove that a dyke of feldspar

porphyry, up to 25 feet wide, strikes north 75 degrees west and continues for over 400 feet. It lies in schistose and highly altered rocks, in large part at least of volcanic origin. Where exposed the dyke is greatly fractured, seriticized, pyritized, and cut by many veins of white to bluish quartz, or of ferruginous carbonate, or of both. There are small pockets of galena in some of the veins, and in the porphyry. In one trench 3 feet of quartz was noted at the south contact of the dyke, but it apparently does not continue to the next trench 100 feet west. Several trenches, for a length of 325 feet, show widths of up to 60 feet of partly carbonatized rocks south of the dyke and some similar material to the north. Much of the carbonatized rock is impregnated and replaced along seams and planes of schistosity by fine-grained pyrite, with very minor amounts of pyrrhotite and chalcopyrite; the schistosity is approximately parallel to the dyke. Intercalated with the carbonatized bands are chlorite schists and grey to greenish, silicified layers, many of which are pyritic. Prominent, also, are lenses and streaks in which chlorite and bright green, chrome-bearing mica are abundant. Left hand displacement has taken place along a set of fractures that strike north 55 degrees east, and dip steeply northwest.

Mr. L. K. Coffin kindly supplied the writer with a report, prepared by J. T. Williamson, on the results obtained from the 1934 work. This report states that the feldspar porphyry dyke was traced for 900 feet, and that mineralization, similar to that described above, was found at intervals over a length of about 1,700 feet and may be continuous. It also states that the gold values obtained by samplying were too low to be considered commercial, though they were found over considerable widths.

Small quartz veins cut the conglomerate and greywacke of the Cadillac group.

The southwestern corner of the group adjoins Sladen Malartic ground and offers some interesting possibilities. Encouraging assays have been obtained near the boundary by Sladen Malartic, and East Malartic Mines has developed excellent ore along the south side of the Cadillac belt in such a position that any westerly continuation might enter the Demara group, although the length before it would again enter Sladen ground is not great. Bedrock is deeply covered by clay and a gravel ridge, so that diamond drilling would seem to be the only method of preliminary examination, unless the underground workings of the adjoining properties eventually reach the Demara boundary.

DEMPSEY CADILLAC GOLD MINES, LIMITED

This company was incorporated in July 1936 to explore a group of ten claims in Cadillac township, and four adjoining lots in Malartic—lots 1 to 3, range IV, and lot 1, range III. The property is north and east of Pan-Canadian Gold Mines. Camp buildings to accommodate about eighty men have been erected in Cadillac township, and early in 1937 a shaft was sunk to 275 feet in range IV, Malartic township. In 1937 and 1938 much diamond drilling was done in different parts of the property. Up to the time the property was examined, in September 1936, only a limited amount of trenching had been done.

Most of the property is underlain by sedimentary rocks of the Cadillac group. The southwestern corner of the claims covers about half the width of the Cadillac belt of the Blake River group, and the easterly nose of the belt in the Heva River drag-fold enters the property for several hundred feet. The Cadillac belt, some 1,500 feet wide, crosses the middle of lot 1, range III, so that a thickness of about 1,500 feet of the Kewagama sedimentary rocks must underlie the southern part of this lot, although there are no exposures.

There are many beds of conglomerate and pebble-bearing greywacke in the Cadillac group, and one or more of white weathering, arkosic quartzite. A narrow band of greenish grey agglomerate is exposed in the northern part of the property. Magnetite beds occur in greywacke in the southern parts of claims A58849 and A58970, southwest of the camp buildings. In the northwestern part of the property, and in the south along and near the Cadillac belt, there are no major deviations from the regional strikes of the strata, but in a broad belt extending 3,000 feet southeast from the easterly nose of the Heva River drag-fold the Cadillac sedimentary rocks are tremendously contorted. A few faults have been recognized in this area, and there is good reason to believe that many more exist but have not been found. The structure is undoubtedly very complex and cannot be completely solved from the comparatively abundant outcrops alone.

The major synclinal axis of the Cadillac group probably crosses the extreme northeast corner of the property, and there is some reason to believe that there are subsidiary minor flexures to the south, in range IV.

The Cadillac belt on the south includes pillowed andesite, amphibolite, chlorite schist, tuff, and sill-like bodies of diorite. Near the south contact the strata are intensely sheared. Small acidic intrusives occur there and in all probability in the adjoining Kewagama group. The volcanic rocks in the easterly nose of the Heva River drag-fold are highly schistose, and are intruded by schistose albite porphyry. Only one small dyke of acidic porphyry was found in the Cadillac group.

There are many quartz veins in the Cadillac sedimentary rocks. Most of them contain no metallic minerals and are probably barren; white mica or biotite and occasional grains of feldspar are the only constituents other than quartz. Many, however, have some arsenopyrite either in the quartz or in the wall-rock. Such veins are most abundant in conglomerate and in siliceous greywacke on a large hill in range IV, Malartic township, and farther west in Cadillac township. Most of them are narrow and lenticular, and occur principally along two sets of nearly vertical fractures. One set lies parallel to the bedding of the sedimentary rocks, the other strikes nearly due east, cutting across the bedding planes at about 15 degrees. In the second set the veins may be in a parallel series, arranged *en échelon* in a single brittle bed, such as conglomerate or quartzitic greywacke in less competent beds, and, unless the brittle bed is very wide, their length is thus not great. In some cases a series of small veins occupies a fracture zone, giving widths of 5 feet or more in which quartz is abundant.

In the northeast corner of claim A58850, the southwestern claim of the property, pebble conglomerate is sheared and intensely fractured, the

schistosity striking due east. In several small exposures, and one in particular just north of a steep-sided, narrow, east-west swamp, this rock is cut by small veins and lenses of quartz and carries fine-grained, disseminated arsenopyrite across widths of a few feet. A short distance north there are numerous small pegmatitic veins of quartz and biotite. The small swamp may overlie a fault or shear zone, as there is a pronounced discordance in strike, and a sharp difference in degree of metamorphism of the strata north and south of it.

The schistose porphyry at the eastern nose of the Heva River drag-fold is sericitized and cut by small, lenticular quartz veins. The strong shear zone at the north contact of the Cadillac belt is quite barren of sulphides in the one trench across it.

Through the kindness of J. J. Coghlan and V. B. Lyle, maps of the diamond drilling done to February 1937 have been sent to the writers. Five holes were put down to explore the easterly nose of the drag-fold at the western side of the property. The results seem to indicate a sharp fold, as shown on Map 575A, and definitely prove that the greenstone and porphyry do not continue eastward. Unfortunately, broken core and poor recovery made it impossible to trace shears in different holes with any degree of certainty, so that the importance of faulting in the folded structure is still a matter of conjecture. The company has announced that no important gold values were encountered in this drilling, although 13 feet of vein material, largely quartz and pyrite in greywacke, was intersected in one hole.

Four holes were put down in the northeast corner of the group in Cadillac township, with no important results reported. Other holes were put down northwest of the shaft to probe beneath a large swamp that crosses the township line.

The two-compartment, vertical shaft is sunk on a quartz vein in sheared conglomerate. The vein is reported to average about 18 inches wide, to pinch and swell, and to dip steeply north. Free gold is reported from it at intervals to a depth of 80 feet, where the vein dips out of the shaft. However, after development on two levels the gold content of the vein was found to be far below the commercial limit and underground operations were suspended in June 1937.

The company had done much stripping and trenching in the southwest corner of the property along the general line of strike of the Pan-Canadian No. 2 vein. A number of small quartz veins have been found, but nothing resembling the vein on the neighbouring property.

Following suspension of underground work in 1937 the company undertook a drilling campaign in lots 1 to 3, range III, Malartic township. Amphi Syndicate did some diamond drilling there, in lot 1, in and south of the Cadillac belt, in 1935, without obtaining much encouragement. The belt consists of highly schistose greenstone with a sill-like body, 260 feet thick, of coarse diorite exposed 70 to 100 feet south of the north contact. There are three beds of conglomerate in the Cadillac group within 800 feet north of the greenstone, the largest about 50 feet thick. Almost equidimensional "blowouts" of quartz in greywacke occur 50 to 100 feet north of the Cadillac belt. The largest, 35 feet wide and about 50 feet long, is

of vitreous to milky quartz; the adjoining schistose greywacke is liberally mineralized, along the contact, with finely divided arsenopyrite and pyrite. Along the strike in both directions, the quartz mass breaks up into a series of narrow veins, which feather out and disappear within short distances. The results obtained from the drilling were disappointing and all operations on the property were suspended in September 1937.

DUNLOP CONSOLIDATED MINES, LIMITED

(Mayrand Option)

In 1936 Dunlop Consolidated Mines developed under option the Mayrand group of fourteen claims in Cadillac township. All but two of the claims are east of Maritime Cadillac. The company has limited its work to diamond drilling on these two claims, A56529 and A56530, south of Lapa Cadillac and immediately north of the centre line of Cadillac township. Seven holes were drilled in 1936 under the supervision of S. C. Yule.

The twelve easterly claims, so far as can be known from scattered outcrops, are underlain by strata of the Cadillac group. In the northwest corner the beds are considerably contorted and, probably, broken by faults and shear zones, but to the southeast they strike uniformly south of east. Several small showings of quartz were noted during routine mapping of the area, but no attempt had been made at that time to prospect the area carefully.

Except for a few small outcrops of greenstone at their southwest corner, the two northerly claims are covered by swamp. The original drilling was planned to investigate the southern part of the Lapa Cadillac drag-fold, where the Cadillac belt had been assumed, from regional geological studies, to turn sharply south toward Maritime Cadillac. The holes were put down at 45 degrees inclinations through 30 to 65 feet of overburden.

The first hole was drilled northeast from a point 30 feet north of the centre line and 875 feet east of the southwest corner of the two claims. Beneath 75 feet of overburden it encountered 37 feet of massive, green andesite with a few quartz-carbonate stringers for the last few feet where the rock is moderately schistose. Then came 5·5 feet of dense, grey albitite, fractured and moderately well mineralized with pyrite, pyrrhotite, and a little chalcopyrite. This was followed by 16 feet of grey to white, porcelaneous quartz albitite seamed with chlorite and cut by small, bluish quartz stringers. Beyond, the drill cut 105 feet of soft mica-chlorite schist, in part highly contorted and traversed by quartz and carbonate veinlets. Then came 180 feet of andesitic lava and tuff, massive to laminated, altered in varying degree and cut by a few quartz veins with some associated sulphides. The company has reported that 5 feet of albitite assayed $12.60 in gold a ton. Two more holes were drilled to the west and proved the continuity of the shear zone and the albitic intrusive for 200 feet. It is reported that the second hole cut 6·5 feet of albitite that assayed $2.10, and that the third showed no important assays.

The shear zone and the mineralized intrusives along its south side strike north 70 degrees west and probably dip steeply south. The shear is about 150 feet wide at the west end, but narrows to the east. The mineralized albitite consists of about 80 per cent albite in small, interlocking grains, 5 per cent quartz that may be almost entirely introduced, and minor proportions of chlorite, hornblende, carbonate, pyrite, pyrrhotite, and chalcopyrite.

Holes three and four gave a horizontal section 800 feet long of the rocks beneath the swamp in a structurally critical area. Northeast of the large shear zone they encountered a succession of andesitic and dacitic lavas with narrow widths of interbedded tuff and greywacke and some narrow shear zones. Several small quartz veins were cut and three carried small amounts of pyrite and arsenopyrite. The interbedded sedimentary rocks are within 225 feet northeast of the shear zone.

No. 5 hole was collared 725 feet north 60 degrees east from No. 1, and was drilled north 40 degrees east at 45 degrees. Near the collar it cut 24 feet of white, fine-grained quartz albitite with small amounts of disseminated arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. The rocks on either side, and particularly for 90 feet beyond, are highly altered to mica and chlorite schists and enclose several quartz veins and narrow, mineralized, silicified zones. Two other small, mineralized, quartz albitite dykes were encountered northeast of the large one. Mr. Yule reports that other holes have shown that the mineralized shear zone, from which low assays have been obtained, strikes about north 25 degrees west, that is, much more northerly than the No. 1 "vein", in fact directly toward the Lapa Cadillac shaft, 2,300 feet away. It would seem that the mineralization is again associated with albitic intrusives in a major shear. No. 5 hole cut interbedded sedimentary rocks, tuffs, and lavas for 225 feet northeast of the shear zone.

The amount of shearing and contortion encountered in the drill holes, and the divergence in strike at the two localities drilled, suggest that the structure will be found to be extremely complicated in detail, and that faulting may be a major problem. On the other hand, the results clearly indicate a continuation of the Cadillac belt and of the Lapa Cadillac type of mineral deposit southward to Maritime Cadillac, confirming a deduction that had previously rested on very meagre surface data.

EAST CADILLAC SYNDICATE

East Cadillac Syndicate controls a large group of unsurveyed claims that cover an area about ¾ mile wide from Malartic township to the centre line of Cadillac township. There are fifty-eight claims, numbered A61644 to A61648 and A61946 to A61998, inclusive, and several fractions. In the area under discussion they lie north of Rubec and Hayes Cadillac and surround the True Fissure property on the north, west, and east. In the autumn of 1936, Messrs. Geoffroy and Koulomzine made a magnetic survey of the property to determine structure and the mineral possibilities.

Immediately northeast of True Fissure, quartz-tourmaline veins have been uncovered in Kewagama greywacke and in porphyry dykes that cut the greywacke. Some of the veins are sparingly mineralized and are reported to carry low gold values.

In the same vicinity a pyritic zone in greenstone near the south edge of the Malartic group has been traced by trenches for about 250 feet. It varies in width up to 35 feet. The sheared volcanic rocks in the zone are silicified and heavily tourmalinized. Pyrite is not abundant. There are many small quartz veins containing albite. Epidote and actinolite are products of alteration. Two drill holes from the south have probed the zone at depth, but no encouraging assays have been reported.

EAST MALARTIC MINES, LIMITED

East Malartic Mines, Limited, controls some 3,300 acres in a single block in northeastern Fournière township, east of the Sladen Malartic mine and the Demara group. The new highway crosses the property. The block of ground is roughly square and is underlain by the Cadillac group in the northern part, by the southern band (Cadillac belt) of the Blake River group in the central part, and by the Kewagama group in the southern part.

The history of development of the property is an interesting example of intelligent prospecting under the difficult conditions that prevail over large parts of northwestern Quebec. The economically important northern part of the property is covered by a deep mantle of clay and gravel except in less than a dozen small areas where rock is exposed. The ground had been prospected with no important results prior to 1930, and following the suspension of operations at Malartic Gold Mines, Limited (now Canadian Malartic), late in 1929, when interest in the area reached a low ebb, all holdings east of Sladen Malartic were allowed to lapse. J. P. Norrie, now Vice-President and General Manager of East Malartic, was manager at Malartic Gold Mines in 1927 and 1928. During that period sufficient drilling had been done to prove that the north ore zone of Malartic Gold Mines extended south of east at least to the Sladen property. Furthermore, large, angular erratics of mineralized porphyry, which could only have been transported by ice, had been found, on ground now held by East Malartic Mines, ½ mile to 1 mile south of the probable eastward projection of the Malartic Gold Mines north ore zone. The erratics resembled material at the Malartic gold mine and had been found to contain gold. It was known, of course, from observations in the district, that the continental ice-sheet had moved east of south over the area, so the erratics must have come from the north. With these facts in mind, Messrs. Norrie and L. K. Coffin, in June 1932, staked the ground now held by East Malartic Mines. Random assessment work yielded no important results, but as the price of gold had risen and interest in the area was reviving, East Malartic Mines, Limited, was incorporated in September 1934 to undertake more thorough exploration. Picket lines were run eastward along the strike of the Canadian Malartic north zone, and also west of north from the gold-bearing erratics. Prospecting was concentrated near the intersection of these lines and along the east-west

lines. John Partanen, an able prospector, did the work and soon made the original gold discovery near the present No. 2 or east shaft, about 7,000 feet from the western boundary of the property. This discovery, however, consisted of narrow auriferous quartz veins in pyritic rock of dioritic appearance, which did not at all resemble the porphyry erratics. Additional prospecting along a picket line from a group of erratics yielded the No. 3 discovery with porphyry. Similar to that of the auriferous erratics, and about 3,500 feet west of No. 1 discovery, No. 2 discovery was made on the east-west picket line between No. 1 and No. 3. Discoveries 1 and 3 were developed by trenches with favourable results, and this was followed by an extensive campaign of diamond drilling. In April 1936, the No. 1 shaft was started to explore the No. 3, or western, discovery and the No. 2 shaft, at Discovery No. 1, was put down during the summer. Underground development has continued since then. In the meantime, however, Sladen Malartic mine had been extensively developed, the ore-bearing zone had been traced eastward to within 1,400 feet of the East Malartic boundary, and a better understanding of the geology of the area had been obtained. The two companies decided to drill at their boundary, to explore the easterly continuation of the Sladen ore zone. Encouraging results were obtained in the first hole, and in 1937 drilling eastward along the south contact of the Cadillac belt proved an important, wide ore-body for a length of 900 feet from the boundary of the property.

During 1937 the No. 1 and No. 2 shafts were allowed to flood and a new shaft, No. 3, was sunk to develop the western ore. The shaft is just south of the highway, 1,150 feet east of the Sladen Malartic property line. During 1938, the mineralized zone was developed to a depth of 670 feet, and an estimated 2,000,000 tons of ore grading about $6 a ton was indicated west of the shaft. A 750-ton mill was erected and went into operation late in the year.

Knowledge of the geology of the property is limited, for it is derived from a few outcrops, from diamond drill cores and records, and from limited underground workings. In the southern part there are outcrops of greywacke of the Kewagama group, only a few of which have been examined in detail by the writers. The exposures visited are well south of the contact with the Cadillac belt and show nothing of unusual interest.

Rocks of the Cadillac belt are exposed in six places north and south of the highway. Drill cores and underground workings give additional information, but the sum total covers only a very small fraction of the area through which the belt passes. From all available data it seems that the Cadillac belt strikes about north 75 degrees west across the property and is some 2,000 to 2,400 feet wide. Fine-grained, sedimentary rocks have been cut in drill holes east of the No. 2 shaft and are exposed in two old strippings. They may belong in the southern edge of the Cadillac group and have been shown thus on the map, although further data would be necessary to prove that they are not merely sedimentary rocks in the Cadillac belt near its northern contact. The southern contact cannot be located within several hundred feet by the few, widely scattered outcrops. Massive, serpentinized rock is exposed at three places south of the highway in the eastern part of the property, and also in a trench that extends

north from the highway a short distance east of the entrance to the camp. This rock is dense, green, and moderately hard to soft. It weathers to a distinctive, soft, pale grey colour that is typical of ordinary serpentine. Some exposures show a polygonal system of joints, which in part are occupied by narrow seams of picrolite or black serpentine. In thin section it consists chiefly of shreds of pale yellow to colourless amphibole and serpentine, the proportions varying greatly, with the serpentine in large part formed at the expense of the amphibole. However, some sections show a granular texture, due to grains about 0·4 mm. across now completely altered to serpentine; these may have been olivine originally. There are many disseminated specks of pyrite and magnetite and a few veinlets of carbonate. Widths of 200 feet of this rock are exposed in two places. In one place it is cut by basic quartz diorite. Although it might be expected, from its composition, to be an intrusive, the rock may be serpentinized basic lava such as is referred to in geological reports on the Bourlamaque area[1]. This rock was seen by the writers only at East Malartic and eastward. Immediately north of the highway, east of the camp entrance, the serpentine is intruded by a body of epidotized diorite some 60 feet wide. A second exposure of diorite was found 2,200 feet west and is 80 feet across. The two exposures suggest the possibility of an east-west dyke in the Cadillac belt, especially as similar material was encountered in drill holes where the eastward extension of such a dyke might pass south of the No. 1 showing. However, similar dykes are known elsewhere in the Cadillac belt, on the property and outside it, so that it is perhaps not safe to assume that the two outcrops mentioned represent a single dyke. In thin section the rock consists of albite (An_4), about one-third of which has been replaced by epidote, about 25 per cent bluish green to pale brown hornblende, and minor amounts of pyrite, apatite, leucoxene, quartz, and magnetite.

The other exposures of the Cadillac belt on the property are in strippings near No. 2 shaft and between the two shafts, just east of the old office building. In both places dioritic material was noted and, at the east, besides chlorite schist there are narrow widths of highly altered mica schist and siliceous, micaceous phyllite, which, as already noted, may belong in the Cadillac group.

Rocks of the Cadillac group are exposed in the north-central and northeast parts of the property. They include normal greywacke and conglomerate. But, 750 to 1,700 feet south of the northeast corner of the property, there are several exposures of highly altered strata of doubtful origin. These include mica and chlorite schists, highly altered conglomerate, amphibolite, one exposure of dark green pyritic porphyry, and some massive green rocks that resemble altered lavas and tuffs. The schistosity strikes practically due east and at the south edge of the largest exposure there is a pronounced 25-foot scarp that suggests a major fault or shear zone. Several fairly large quartz veins were noted at the west end of the exposures.

Acidic intrusives are known only in the Cadillac belt around the mine workings, and will be described in that connection.

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[1] Bell, L.V.: Que. Bur. Mines, Ann. Rept. 1934, pt. B.

At the time the property was examined in 1936 work was concentrated in two areas, around the No. 1 and No. 3 discoveries.

The original discovery was a low, moss-covered knoll that was easily stripped for a length of 80 feet and a width of 25 feet. Over half the outcrop consists of a dark, crystalline, basic rock, of dioritic appearance, that is cut by many small quartz veins and carries much fine-grained pyrite. Widths of 20 feet of this material are exposed, and many of the quartz veinlets contain small grains of gold. The pyrite is most abundant alongside the quartz veins, but also occurs throughout the rock, tending to form streaks. Ferruginous carbonate accompanies the quartz. The dioritic rock contains inclusions of schist, and is variable in grain and appearance, the freshest phases being very dark and resembling fine-grained diabase. On the east, however, this rock, which at first inspection would be taken for a dyke, and which may include some dyke rock, is seen to pass irregularly and in places gradationally into green, mica-chlorite schist and into dense grey to brown, silicified rock that carries some green chrome-bearing mica and is probably altered tuff or greywacke. Under the microscope, about 60 per cent of the freshest phase of the "diorite" is seen to be crystals of albite, up to 1·5 mm. across, crowded with inclusions of biotite, hornblende, chlorite, pyrite, and magnetite. The rest of the rock is an intergrowth of these included minerals, and, in addition, carbonate in abundance, and a little quartz and apatite. The rock is not a normal intrusive; it has the characteristics of a hybrid rock, both by occurrence, composition, and texture.

Sampling of the quartz-veined, pyritic rock is reported to have yielded commercial values across widths up to 17 feet. After considerable trenching in deep clay, diamond drilling was commenced, and eighteen holes were put down. Only four of these holes were logged by the writers to serve as a guide to data supplied by the company. Five holes were drilled east of the discovery, the farthest 550 feet from it, the closest 120 feet. None of these encountered anything that could be safely concluded to be the easterly extension of the discovery. They did cut narrow widths of similar material, however, in chlorite schist, particularly in the easterly holes, at the north contact of a body of grey albite porphyry, which, so far as the data indicate, is a fairly narrow dyke dipping gently southward. In hole 31, near the east end, chalcopyrite occurs in the dioritic material in some abundance. The porphyry body, or a similar one, is exposed in a trench 25 feet south of the discovery, and carries disseminated pyrite. The first hole to the east cut 10 feet of the porphyry, mineralized with pyrite and arsenopyrite. This is the only place on the property that the writer observed arsenopyrite. The easterly holes cut serpentine and chloritic schist, and, in their northern parts, considerable widths of slaty to siliceous, sedimentary rocks, separated by narrow bands of mica and chlorite schist. These facts, studied in conjunction with the available outcrops in the area, indicate that the discovery showing is at or very close to the northern contact of the Cadillac belt, where interbedding of volcanic and sedimentary rocks may be expected. The hole closest to the discovery cut basic diorite and amphibolite at its south end, some 180 feet south of the discovery. Small amounts of pyrite and chalcopyrite were noted in the diorite.

Thirteen holes were drilled under and for 800 feet west of the discovery. The country rock in the holes logged, and presumably in all, is massive to schistose serpentine and chlorite schist, in places greatly contorted or brecciated and recemented by carbonate. The harder, more massive varieties are in the southern part of the area drilled and probably include some andesite. The holes also encountered the westerly continuation of the surface discovery, and indicate that it is an irregular, lenticular body, striking a little north of west, at least 320 feet long, and about 25 feet in maximum width. The average width would appear to be between 10 and 15 feet for the length outlined. Some core sections show a mottled pale green to grey, siliceous rock, sparingly mineralized, with an abundance of bright green chrome mica, very similar to parts of the Demara carbonatized and silicified zone.

The drilling also showed the presence of other lenticular bodies of the same type of material north of the western extension of the discovery body. Several such bodies were encountered in different holes, and they varied considerably in their content of quartz and pyrite. The principal one was cut in nine holes over a length of 620 feet; its east end lies less than 20 feet north of the western part of the discovery body, and, indeed, the two bodies may join. The body as outlined by drilling, though curved, strikes north 72 degrees west on the average. It is about 15 feet wide in the eastern part and narrows to a few feet in places on the west. In some of the core there is rather convincing evidence that the pyritic, dioritic rock is due to replacement of the chloritic schists in which it lies, for the contacts against the schist are clearly gradational and there are streaks and narrow widths of schist in the "diorite". It may be that there was some dioritic intrusive rock along the zone in which the ore occurs, or that the "diorite" has formed at the expense of sedimentary layers in the schist, but the cores do not suggest an intrusive origin for the whole body.

The No. 2 shaft was being sunk at the time the property was examined. It is 300 feet west of the discovery, and starts on the northernmost of the two bodies outlined by drilling. There was no opportunity for study of the shaft, but material identical with the discovery showing had been encountered above the first level. The strike of schistosity at the first level is north 75 degrees west, the dip rolling to vertical. The dip of the ore-bodies is said to be very steep to the north.

If the rather meagre data available have been rightly interpreted and the ore lenses are replacement bodies within a few hundred feet of the north contact of the Cadillac belt, in a heavily sheared zone, it is interesting to note that the Demara deposit, 7,000 feet west by north, lies at about the same horizon, and although not identical, is similar in occurrence and type. Furthermore, that if a similar type of mineralization persists between the two deposits, under drift-covered ground, the zone would pass north of the area that has been developed around the East Malartic No. 1 shaft.

The No. 1 shaft, at the No. 3 discovery, is 3,600 feet north 83 degrees west from the No. 2 shaft. The mineral discoveries there are quite different from those at the No. 2 shaft. The original trenching, now largely filled in, showed that a body of quartz syenite porphyry intrudes chlorite

schist and serpentine of the Cadillac belt, and also disclosed a few dioritic bodies in the volcanic rocks. Several trenches near the shaft revealed a number of quartz veins carrying pyrite and some galena in the porphyry. Twenty diamond drill holes partly outlined the porphyry mass, as shown on Map 573A and revealed a second intrusive mass a short distance to the north. It is reported that assays sufficiently high to justify underground exploration were obtained from silicified zones in the porphyry near its north contact, and that other encouragement was met with both to the south and to the north, in the second intrusive body. In September 1936, two levels, at 175 and 325 feet, had been established, and 750 feet of development carried out, principally on the first level.

The diamond drilling indicates that the quartz syenite porphyry is very irregular in outline, is at least 1,800 feet long from east to west, and near the shaft is not less than 800 feet wide. To the east and west of the shaft section it narrows abruptly. Normally, it is a grey, holocrystalline, even-grained to porphyritic rock. Albite (An_2 to An_4), as phenocrysts up to 2·5 mm. across, is abundant in a moderately coarse groundmass of albite and quartz. Accessories and alteration products include biotite, sericite, pyrite, carbonate, apatite, chlorite, and magnetite, biotite being the most abundant. Alteration, presumably by mineralizing solutions, has imparted pink and brown colours to parts, and locally the rock shows microscopic evidence of crushing. Sericite has developed principally at the expense of feldspar, and chlorite replaces biotite.

The volcanic rocks are similar to those at the east shaft, and consist of serpentine and chlorite schist, locally converted to amphibolite or soft, talcose, chlorite schist, and cut by many calcite stringers. North of the porphyry, at the west end of the drilled area, there is at least one band of dioritic rock, similar to the one at No. 2 shaft, mineralized with pyrite and accompanied by quartz veins in which there is some tourmaline.

The second intrusive body, north of the shaft, is only partly outlined by the drilling. It is 300 feet wide in one place and not less than 800 feet long. At the mine it has been termed quartz porphyry to distinguish it from the syenite porphyry, for it contains a few phenocrysts of quartz, up to ½ cm. across. However, an examination of cores and thin sections indicates that the quartz phenocrysts are local features; otherwise the two rocks are very similar in appearance and composition. Small amounts of apparently residual orthoclase were noted in some of the albite phenocrysts. Like the syenite porphyry, the rock carries pyrite and is cut by quartz veins. Some chalcopyrite was noted in the core.

No. 1 shaft is sunk in quartz syenite porphyry. The north contact of the body has been cut in both levels and dips 75 to 80 degrees south, but locally the dip is reversed for short distances. North of the porphyry is soft, contorted, chlorite schist, traversed by carbonate seams and broken by gouge-filled fault planes. The principal fault planes are parallel to the contact and about vertical, and drag-folds in the schist indicate that the south walls have been thrust upward and probably westward.

On the first level a crosscut had been driven 125 feet south from the shaft, in porphyry that is much fractured and cut by numerous small veins of quartz and calcite with considerable specularite. Where these small veins are particularly numerous the porphyry is altered from its normal

grey tone to brown or pink. Some of these veins cut quartz stringers and there are also many seams of pink albite that carry specularite and chalcopyrite. Thirty feet south of the shaft a shear zone, defined by two fault planes that dip steeply south, was encountered and followed by drifts to the east and west. For 100 feet to the west the shearing persists, but quartz lenses along it are discontinuous and narrow. To the east, however, an improvement took place within 50 feet, and the drift had been continued another 15 feet in this "178" vein. This vein, or mineralized zone, follows the shearing, which at 50 feet east dips 65 degrees southward. The hanging-wall of the sheared zone is occupied by a vein of white quartz 1 to 4 feet wide, sparingly mineralized with pyrite, galena, and chalcopyrite, and carrying inclusions of greenish, sericitized porphyry. On the north or foot-wall side the porphyry is cut by quartz stringers, and is in some places sericitized and grey and in others silicified and altered to a brown, pyritic rock that retains its porphyritic texture. In the one crosscut that had been driven to the north the intense alteration persisted for about 30 feet north of the vein. The company's assay plan shows erratic values of $1 to $15 a ton across the width of altered rock. It has been reported that drifting and raising eastward on the 178 vein have proved a length of 250 feet of ore, averaging about $7 a ton across 9 feet, and that free gold has been encountered in the vein.

On the second level the crosscut had been driven 25 feet south in porphyry and 60 feet north to the contact without encountering any important deposits. A slight flattening in dip of the 178 vein would carry it south of the end of the second level crosscut. On neither level did the north contact of the porphyry show important deposits, but a raise was being driven above the first level, at the contact, to intersect a drill hole, some 20 feet above the level, which had indicated ore for 13 feet of core.

The writers are indebted to E. A. Goranson, company geologist, for geological data on which the following notes concerning developments in 1937 are based.

The No. 2 shaft was sunk to 350 feet and levels were established at 175 and 325 feet. Over ½ mile of underground work and much diamond drilling on these levels have been reported by the company as having indicated 200,000 tons of ore that will average about $8 to $9 a ton in gold. The workings are in greenstone and soft, chlorite schist, with a few intercalations of slaty sediment. The ore, referred to as "diorite" and silicified schist, is similar to the pyritic "diorite" at the surface, as described earlier in this report. It occurs as lenticular or irregular, sheet-like bodies in schist, the average dip down the shaft being 80 degrees northward. Visible gold is reported as fairly abundant in the ore, principally in small quartz veins. Pyrite is the principal sulphide. The ore-bodies are offset by cross-faults and vary greatly in size. In places they are heavily jointed and fractured.

Early in March 1938, the company reported that the first level in the No. 3 shaft had been driven west along the new ore zone to within 50 feet of the west boundary of the property. It was also reported that the last 800 feet showed continuous ore. Lateral work is said to have indicated ore of about $7 a ton in gold across an average width of 33 feet in this distance.

Maps of the surface drilling in this section show that sixteen drill holes probed the ground from the shaft to the west boundary of the property. They were all drilled through deep overburden. The ore-bearing zone lies along and north of the contact between greywacke on the south, and the Cadillac belt on the north. The average strike is a little north of west and the dip very steep to the south. The greywacke is not greatly altered except close to the contact, where it is silicified and generally in part auriferous, in an irregular manner across widths up to about 30 feet. The volcanic rocks of the Cadillac belt, on the other hand, are intensely sheared and are cut by many porphyry dykes. There are also bodies of "diorite" and diabase. The "diorite" is similar to that encountered at No. 2 shaft and, consequently, of doubtful intrusive origin. The diabase is a fresher and less pyritic rock of basic composition. Gold is reported from soft schist, from "diorite", and from silicified porphyry, and although in general persistent along the contact zone has also been encountered in isolated sections to the north. The shear zone apparently ranges from 100 to at least 220 feet wide, and the assemblage of chlorite and mica schists, with talcose to serpentinous phases, abundant carbonate, and gouge-filled fissures, is reminiscent of the main Cadillac "Break" as it is exposed in mine workings in Cadillac township.

Late in 1937, ten drill holes from the surface probed the contact zone for 1,100 feet east of the new shaft. They defined the contact, indicated geological conditions somewhat similar to those to the west, and returned a number of auriferous sections along the contact zone. Several feldspar porphyry dykes were cut in the greywacke, and it would appear that the sheared zone narrows considerably. At least the drilling indicates that ore may be found east of the shaft as well as to the west.

A length of 2,300 feet along the contact of greywacke and greenstone has now been probed by drill and underground workings, and very substantial ore reserves have been indicated. It is worthy of note that 2 miles of this contact remains unexplored to the east, except for a little section south of the No. 1 shaft. It is also significant that auriferous deposits have been found in the same horizon on other properties still farther east.

HAYES CADILLAC MINES, LIMITED

This company owns thirteen surveyed claims in Cadillac township immediately east of Rubec mines and north of Lapa Cadillac and Sladen Malartic's Cadillac holdings. Limited surface work was done on the property in 1936, and in 1937 about 5,000 feet of diamond drilling was completed.

The few exposures on the property are in the south-central and western parts. These show greywacke, iron formation, and a little conglomerate of the Cadillac group. In the western part the strata strike a few degrees south of east, but in the central and eastern parts they swing southeastward in conformity with the regional structure. With the exception of the northeast corner, which may be underlain by Blake River volcanics, the whole property is probably on sedimentary rocks of the Cadillac group.

A number of quartz veins, some bearing a little gold, have been found in the sedimentary rocks. In the spring of 1937 a drill hole was put down

from the southwest corner of claim A58753. The company states that it cut 350 feet of dense, porcelaneous to porphyritic quartz albitite. A second hole drilled from the north and to the east of the first encountered the same rock, which is apparently identical in appearance with that cut in a drill hole at the south side of the Rubec property 1,900 feet to the west. If, as seems probable, the two occurrences are part of the same body, a sill-like intrusive 200 feet wide striking just south of east is indicated. The company reports quartz stringers with pyrite in the intrusive, particularly for a width of 15 feet or more at its north contact where the greywacke is highly altered and carries arsenopyrite besides quartz and pyrite. Minor quantities of gold have been reported from core from the north contact zone, and also from at least one narrow mineralized zone well within the intrusive.

If the intrusive is parallel to the strike of the sedimentary rocks and continues eastward, it would be expected to bend southeastward within about 1,000 feet east of the Hayes Cadillac drill holes, following the structure toward Sladen Malartic claims.

LAPA CADILLAC GOLD MINES, LIMITED

Reference: Gunning, H. C.: "Cadillac Area, Quebec"; Geol. Surv., Canada, Mem. 206, pp. 68-71 (1937).

This company owns twenty-two claims in the northeast quarter of Cadillac township. The property and developments to 1935 are described in Memoir 206. In 1936 a three-compartment shaft was sunk and a level established at 165 feet. Late in September, when the property was examined, a crosscut had been driven 180 feet north into the zone in which gold had been encountered in drill holes. The shaft is 40 feet north of the collar of drill hole No. 4, the most easterly one of the 1934 drilling campaign. During 1937 and 1938 the shaft was deepened, two new levels established at 290 and 540 feet, and much underground work and diamond drilling performed on the three levels and from the surface. A 250-ton mill went into operation in July 1938, but the extraction, by amalgamation, proved unsatisfactory. Milling was resumed in January 1939, after the addition of a cyanide unit. The senior author made a brief examination of the property in October 1937. Denison Denny is managing director and F. J. Sugden is geologist.

There are few outcrops on the claims and none near the mine workings. From very fragmentary information it seems probable that the shaft, in the Cadillac belt, is on the north limb of a major, sharp drag-fold, as indicated on Map 575A. It is impossible as yet to decipher the details of the structure. Previous drilling indicates that the shaft is about 300 feet northeast of the south contact of the Cadillac belt, and that for several hundred feet north the rocks are highly sheared. Southwest of the contact there may be about 500 feet of greywacke of the Kewagama group north of contorted and faulted greenstone and schist of the southern part of the drag-fold. There are several outcrops of greenstone in the southwestern part of the property and a few of greywacke, all somewhat schistose and in part greatly contorted. Drag-folds in some of the greenstone plunge at 50 degrees or so to the west or northwest.

Along the crosscut on the first level, north of the shaft, dark green, soapy, chlorite-biotite schists with many lenses and streaks of calcite strike north 75 degrees west on the average and dip 70 to 80 degrees north. Farther north the schists vary more in appearance and on the whole are more micaceous, but maintain the same attitude. Immediately north of the station the schists are intruded by a massive dyke of creamy grey, porcelaneous quartz albitite, 35 feet wide, that dips irregularly 75 degrees north. It is cut by small quartz stringers and contains seams of pyrite and chlorite. At each contact, for a foot or so, the rock is dense, cherty, and almost white. A few feet of similar rock is exposed at the southeast corner of the shaft, and a small lenticular body occurs in schist 175 feet north.

The only other intrusive rock in the crosscut is dark grey, finely crystalline albitite. Four dykes cut the schists, 55, 68, 90, and 160 feet north of the station, respectively, the largest about 10 feet wide. Even in the width of the crosscut the albitite bodies are exceedingly irregular in outline and, evidently, may be expected to pinch and swell suddenly on strike and dip. Generally much fractured, seamed with chlorite, and cut by small quartz veins, they are sparingly to heavily mineralized with fine-grained arsenopyrite, pyrite, pyrrhotite, magnetite, and rare chalcopyrite. The nearly pure albite that forms the bulk of the rock is remarkably fresh, with a few phenocrysts up to 2 mm. long in a fine-grained groundmass. There is little or no quartz and only minor amounts of carbonate, brown biotite, chlorite, sericite, and apatite.

The crosscut from 110 to 125 feet north of the station is crossed by two bands of hard, laminated, brownish grey rock that somewhat resembles albitite and, like that intrusive, is mineralized with quartz, arsenopyrite, and iron sulphides. The microscope shows that the rock is highly carbonatized schist, possibly altered sedimentary rock rich in residual quartz grains.

A few northeasterly striking faults, dipping vertical to steeply northwest, cut schist and albitite. The displacement on one is left hand, the horizontal offset 2 feet.

There are many small quartz veins in the schist and albitite, but they are particularly abundant from 72 to 170 feet north of the station. Most of them are small and discontinuous or lenticular; two or three attain widths of 10 inches and persist across the crosscut. The quartz is white, grey, or mottled, but, in a 27-foot interval along the crosscut, several veins, including one that attains a width of 4 feet, are dark brown and cherty or flinty, with streaks and partings of schist that suggest that these veins have formed by replacement. The dark colour is due to many microscopic needles of tourmaline. The tourmaline, like the quartz, is exceedingly fine grained; the tiny needles average about 0·08 by 0·01 mm. It is practically colourless in thin section and is intimately intergrown with the quartz. Microscopic veinlets of quartz, without tourmaline, cut the earlier quartz-tourmaline intergrowth. Visible gold was noted by the writers in five different veins, at 85, 117, 143, 157, and 170 feet north of the station, in small specks and seams in the quartz and in the schistose inclusions. It does not seem to be associated with the rather scarce sulphides in the veins.

Mr. Denison Denny has kindly supplied the writers with geological maps, prepared by Mr. Sugden, of the mine workings up to January 1938. Preliminary efforts were concentrated on the development of "A" and "B" zones, by drifts 100 feet east and west from the main crosscut on the first level. "A" zone is 85 feet north of the shaft; along it many small quartz veins have been exposed in and near an irregular sheet of albitite. The width of the zone is indefinite, being determined solely by the widths across which gold-bearing quartz stringers are abundant. Zone "B" is 170 feet north of the shaft on the first level and is some 30 feet wide at the main crosscut, but is also poorly defined. Cherty, brown, quartz lenses and veins and some mineralized albitite occur in it, but no persistent veins have been found.

Another type of ore was eventually found in the "C" ore-body, about 60 feet north of the "B" zone on the first level. The body is oval in horizontal cross-section, 60 to 80 feet long, and up to about 18 feet wide. It has been found on all three levels of the mine and is in the form of an oval pipe that plunges at about 65 degrees to the north. It lies near the north edge of the broad shear zone and is encased in mica-chlorite schist. The ore is a massive, hard, brownish grey rock, traversed by minute veins of quartz and albite and liberally mineralized with fine-grained, disseminated pyrrhotite, arsenopyrite, pyrite, and a little chalcopyrite. Under the microscope the mineralized rock is seen to consist of a granular mixture of albite and a little quartz, biotite, chlorite, and carbonate, and cut by quartz veins. There is a small proportion of disseminated tourmaline. The maximum grain size is about 1 mm. Some finely divided native gold has been seen in the ore. The ore appears to be a replacement deposit in the schist, as around the edges there is a narrow gradation from it to barren schist, particularly apparent on the ends of the lens, where the schistosity trends into the ore instead of bending around it. The least highly altered phases closely resemble biotite and chlorite phyllite that commonly develops from the alteration of greywacke in the area. Almost identical rock, less heavily mineralized, has been found just north of the ore-body and traced eastward for several hundred feet. It contains minute, glassy, quartz "eyes", and is probably a bed of greywacke or tuffaceous greywacke in the schist. Some encouraging gold assays have been obtained from parts of it.

Auriferous material of low grade, but otherwise similar to the "C" body, has been encountered on all levels in the eastern extension of the "A" zone. It is reported that an ore-body of this kind has been developed for a length of 100 feet and an average width of about 12 feet on the bottom level. It requires much development work to explore fully the broad zone of schist, 400 feet wide, for such bodies, and for the smaller enrichments that may occur in zones of the "B" type.

The work that has been done by the company has added many details to the knowledge of the structure in the mine area. Underground work and drill holes show that the strata about 600 feet east of the shaft are bent sharply south, and judged by limited developments in this area on the three levels the sharp fold seems to stand nearly vertical. Data are insufficient as yet, however, to show the exact significance of this fold in relation to the major Lapa Cadillac drag-fold.

During the summer of 1936 two long drill holes were put down to explore beneath a swamp southwest of the shaft, where data were needed to check structural hypotheses. The geology along the holes, somewhat generalized, is shown on Map 575A. The holes have shown a thickness of 950 feet of andesitic volcanic strata of the Cadillac belt. The rocks vary from relatively fresh lavas and tuffs to chlorite and mica schist and carbonatized, crushed material. The largest of several pronounced zones of shearing and brecciation is 125 feet wide, providing it strikes about at right angles to the holes, and is about 100 feet south of the north edge of the Cadillac belt. The north edge of the belt was placed by the writers where fine-grained sediments first appeared in the core, interbedded with tuffs and possibly some thin altered flows. Other narrower shears were cut south of the large one, and eight, small, mineralized, albitite dykes lie in the first 275 feet south of the edge of the main shear zone. Low gold assays were obtained at two places, from quartz and from mineralized schist alongside a small quartz albitite dyke. Several other small quartz veins were noted in the core.

Map 575A shows a generalized interpretation of the structure on the property, based on very inadequate data. It is important to note that the mineralized zones apparently follow the schistosity, as do the numerous small sodic intrusives. Besides defining the limits of the Cadillac belt, particular attention should be paid to tracing the strong shears that occur in the belt, as they undoubtedly exert control on the location of mineralized zones. It is not known yet whether these shears are folded with the belt, or were formed later than or accompanying drag-folding. In the latter case they would not be confined to the greenstone belt.

LARTIC MINES, LIMITED

Lartic Mines, inactive since 1929, holds the north halves of lots 2 to 6, range III, Malartic township. Two old shafts in lot 4 are flooded to the collars. Many of the trenches are caved or are grown over, and the buildings are dilapidated. Some diamond drilling was done in 1929 before the property was closed.

Bedrock is principally greywacke of the Cadillac group. The north contact of the Cadillac belt of the Blake River group lies approximately at the southwest corner of the property. The greywacke in general strikes 30 degrees south of east, but local contortions change the strike as much as 90 degrees; the schistosity strikes uniformly 30 degrees south of east. Three beds of conglomerate, within 800 feet north of the Cadillac belt, are exposed on lot 1, and probably continue southeast under drift on lot 2. The largest is 50 feet thick.

Several carbonatized, chloritized zones, some of which contain beds of almost solid magnetite, are best exposed at the east end of the ridge in lot 4; the zones range in width from 10 to 40 feet; the most persistent one is 10 feet wide and is continuous for 770 feet, crossing the full length of the outcrop. Similar zones are exposed in trenches 650 feet and 1,020 feet west of the west end of this zone, giving a possible total length of 1,800 feet. The rock within the zones consists of highly schistose, heavily

chloritized and carbonatized greywacke with some contorted magnetite bands. The carbonate, which weathers rusty and is presumably ankeritic, is present in veins through the greywacke or as subhedral, evenly distributed crystals in chlorite schist. Finely divided pyrite is quite abundant in some places.

The main showing, explored underground from the shafts, is on the extreme northeast corner of the large outcrop in lot 4. It consists of a series of quartz veins as much as 8 inches wide in greywacke, which is heavily mineralized over widths to 5 feet. East of the dump the vein system has been traced for a length of 110 feet by seven short trenches, beyond which the vein is hidden by drift. West of the dump the vein system consists of thin quartz stringers more or less continuous for 200 feet along the north side of the outcrop to the edge of an area of drift. One lenticular mass of white quartz, north of the main zone, is 30 feet long and up to 8 feet wide. It carries some sulphides and the adjoining greywacke on the south is heavily mineralized across 1 to 3 feet. The quartz of the main showing is milky to vitreous. The country rock is biotized, amphibolitized greywacke impregnated with pyrite, pyrrhotite, and coarse arsenopyrite. No underground observations were possible, but most of the material on the dump is greenish, amphibolitized greywacke similar to that exposed at and near the veins on the surface. However, what was apparently the last material thrown on the dump is more normal, even-grained greywacke with a little disseminated pyrite. It is reported[1] that underground work was abandoned because a "faulted condition" was encountered.

LASALLE GOLD MINES, LIMITED

LaSalle Gold Mines, Limited, holds parts or all of lots 15 to 20 and 22 to 25, inclusive, in range VII, Malartic township, as well as water claims on Malartic Lake opposite lots 17 to 21 and 23 to 25, inclusive. The property is easily accessible from Malartic Lake. Very little development work had been done on the holdings when the writers visited them in 1936.

The claims are underlain by volcanic and sedimentary rocks of the Malartic group, by several dykes of serpentine, small dykes of feldspar porphyry and lamprophyre, and by a thick sill of granodiorite. The Malartic strata strike northwest and dip vertically to steeply southwest. The lavas are basic to intermediate, and are accompanied by some breccia. Pillow structures are well developed in places. The rocks are uniformly hard and massive except north of the granodiorite on the point in lot 22, where the lavas are moderately to highly schistose. Sedimentary rocks are not exposed on the claims, but must extend into lots 22 and 19 because a width of about 500 feet of conglomerate and greywacke is exposed on lots 20 and 21, the property of Malartic Lakeshore Mines, Limited.

Two dykes of serpentine intrude the lavas near the south side of lot 18. The adjoining country rock is bleached and altered. A pit on the

[1] Que. Bur. Mines, Ann. Rept. 1929, pt. A, p. 139.

north contact of a smaller dyke 1,000 feet farther north disclosed a small deposit of coarsely crystalline calcite with some small plates of talc, a little tourmaline, and a few grains of chalcopyrite. Small, barren veins of quartz accompany several of the minor dykes of porphyry and lamprophyre. Small quartz-tourmaline veins in greenstone were also noted in the southern part of lot 19.

On lots 20 and 21, held by Malartic Lakeshore Mines, several quartz veins have been opened by trenches in the volcanic and sedimentary rocks. Some of the veins are mineralized with pyrite, sphalerite, chalcopyrite, and galena, and at least one carries gold. There are also pyritic siliceous replacement bodies in the sedimentary rocks on this property. Similar deposits may occur in the adjoining LaSalle ground. Of possible importance also is the fact that, near the east side of lot 21 and 1,400 feet north of its south end, there is an abrupt swing in the strike of the sedimentary beds from north 15 degrees west to north 45 degrees west. The critical area is drift covered on LaSalle ground, but the structural disturbance must extend to lot 22. On lot 21 the strata are contorted and broken at the bend, and quartz-tourmaline veins have been introduced into some of the fractures.

The exposures of granodiorite along the lake shore in lots 20 to 25 constitute the northwestern end of a sill, here 1,200 to 1,500 feet thick, which extends southeastward to lot 49, range V. The granodiorite is a highly schistose, dark green rock with waxy lustre on fresh surfaces. Small, round grains of bluish quartz, ordinarily visible in hand specimens, are set in a groundmass the grains of which have been sheared out beyond recognition. Much of the granodiorite is severely brecciated; the breccia, in places, is highly silicified and mineralized with disseminated pyrite. This type of breccia is well exposed on the lake shore near the lot 19-20 line, and again near the lot 20-21 line. The first of these exposures had been sampled, but no reliable information as to the assays could be obtained at the time of the visit.

LOTS 14 TO 18, RANGE IV, MALARTIC TOWNSHIP

Sedimentary rocks of the Cadillac group are well exposed on the north halves of lots 14 to 18, range IV, Malartic township. The beds strike north 60 degrees to 70 degrees west and consist of greywacke, a few narrow beds of tuffaceous conglomerate, and several thin beds of impure iron formation. The sedimentary rocks are cut by many quartz veins of the Cadillac type—lenticular, small veins some of which are accompanied by small amounts of pyrite, arsenopyrite, and tourmaline. There are also occasional lenticular masses or "blowouts" of quartz several feet across. A bed of tuffaceous conglomerate at the east end of the outcrops, besides being cut by quartz veins, is in part replaced across several feet by quartz and tourmaline. It was reported to the writers in 1936 that encouraging gold assays had been obtained from some of the veins.

As pointed out earlier in this report under "Structure," faults of considerable offset may cross range IV.

LOT 35, RANGE II, MALARTIC TOWNSHIP

The northern band of the Blake River group crosses the northern part of lots 34 and 35, range II, Malartic township. The volcanic rocks are highly altered, in large part to slaty and fissile chlorite schist, but include some massive andesite. About on the boundary between the two lots, and 1,000 feet south of the northern range line, the outcrops end at an abrupt scarp, 20 to 30 feet high, that forms the north edge of a large swamp. The scarp trends north 73 degrees west for 3,500 feet. The presence of the scarp and the occurrence of intense shearing along it suggest that there may be a fault in the low ground to the south. Some old trenches on and north of the scarp reveal rusty schists and one zone about 2 feet wide that is intensely carbonatized and replaced by white mica, arsenopyrite, and black tourmaline. There are also small, irregular quartz veins. Other small quartz-tourmaline veins were noted westward along the high ground above the scarp.

LOTS 18 AND 19, RANGE V, MALARTIC TOWNSHIP

The complicated structure of the northern band of the Blake River group in lots 18 and 19, range V, Malartic township, is discussed earlier in this report under "Structure." Several veins are exposed in this area. Two short quartz lenses, one 80 feet long and 5 to 15 feet wide, the other 50 feet long and 5 to 30 feet wide, outcrop near the south side of lot 19. The veins carry chlorite and muscovite, but little if any sulphide. Another, more interesting, vein is exposed for 70 feet across an outcrop of schistose conglomerate and tuffaceous greenstone in lot 18. The vein proper is 2 to 8 inches wide, and the walls are heavily carbonatized over widths of a few inches on either side. Northeast on the strike 550 feet away on the northern tip of an outcrop of conglomerate, there is a network of quartz veins with much carbonate, possibly the continuation of the vein. Fifty feet north of the vein is a zone of carbonatized greenstone 15 feet wide, which is exposed for 150 feet along the strike. Some surface work has been done on these showings. If the presence of gold could be confirmed the area should repay closer examination.

MALARTIC GOLDFIELDS, LIMITED

This company owns a large block of claims in northeastern Fournière township and extending north into Malartic township and east from Rand Malartic into ranges VIII and IX, Dubuisson township. Over most of the property bedrock is deeply buried by clay and swamp. Exploration, principally since 1935, has been carried out by magnetometer surveys, a limited amount of trenching, and many thousands of feet of diamond drilling. During 1936 comfortable camp buildings were erected on Piché River in Fournière township, one mile south of the highway.

South of the highway in Fournière township the only outcrops are a few small ones of conglomerate and greywacke at the south side of the

Cadillac group, and some exposures of Kewagama greywacke south of the Blake River group, at the rapids in Piché River. A few small, pegmatitic veins of quartz with coarse biotite and a little pyrite are exposed in the conglomerate, and one vein contains small amounts of gold.

Since 1936 drilling has been concentrated in and along the south contact of the Cadillac belt. Information supplied by the company's geologist, E. A. Goranson, shows that the belt is about 2,400 feet wide in Fournière township. The schists and greenstone are cut by dykes and irregular bodies of porphyry that are particularly abundant towards the south contact and also intrude the northern edge of the Kewagama group. There are also bodies of diorite similar to that encountered on properties to the west. Drilling done in 1937 probed the southern part of the Cadillac belt and the adjoining greywacke of the Kewagama group for about 3,000 feet between Piché River and the Rand Malartic boundary. The volcanic rocks are intensely sheared in the contact zone and the many bodies of diorite and acidic porphyry seem to be exceedingly irregular in shape. It is reported that gold was found in many holes, particularly in porphyry. Late in 1938 the company is reported to have obtained unusually encouraging results in drill holes in the northern part of the Cadillac belt, some 8,000 feet from the west boundary of the property. Much of the gold is said to occur in pyritic "diorite" in greenstone. It is stated that a shaft is to be sunk to a depth of 500 feet to explore the discovery.

MALARTIC LAKESHORE MINES, LIMITED

This company reports that it holds lots 19 to 24, range VI, and lot 21 and the south half of 20, range VII, Malartic township. Considerable surface work was done in range VII by Mr. Ledoux of Malartic Lake prior to 1936.

Lots 23 and 24, range VI, are entirely drift covered. Lots 19 to 22 are underlain by flows and fragmental rocks of the Malartic group cut by many small feldspar porphyry dykes and dykes of serpentine. In addition, a large dyke of gabbro crosses the centre of the western lots. It has a maximum width of about 400 feet and strikes southeast, parallel to the volcanic rocks. No noteworthy mineral deposits associated with this dyke were seen on the company's ground, but elsewhere in the area quartz veins and some sulphides occur along its contact.

Lots 20 and 21, range VII, are partly underlain by volcanic rocks of the Malartic group that strike northwest and dip vertically to steep southwest. They include andesitic to dacitic lavas and related fragmental rocks. On the northeast they are bordered by an exposed thickness of about 500 feet of sedimentary strata. A wide area northeast of the sedimentary outcrops is drift covered. The sedimentary strata consist of a maximum thickness of about 400 feet of conglomerate on the southwest and 100 feet or so of fine-grained, laminated, arkosic and argillaceous strata on the northeast, in part altered to mica schist. The conglomerate is of an unusual type. It is a grey weathering, siliceous rock with scattered layers and groups of angular to rounded, acidic pebbles up to about one foot in diameter. Included are large proportions of grey to greenish, siliceous, banded strata that are interpreted as tuffs and greywacke, with

possibly some rhyolitic flows, all in large part converted to quartz-sericite schist. In one place the conglomeratic horizon is bordered on the southwest by greyish green agglomerate, in another by schistose andesitic lava; elsewhere the contact is drift covered. Volcanic and sedimentary rocks are intruded by a few small dykes of feldspar porphyry, amphibolite, and lamprophyre.

The strata are broken by a number of cross faults with small offsets, and are locally contorted. The most important structural feature is an abrupt swing in the strike of the sedimentary beds from north 15 degrees west to northwest near the southeast end of the exposures. The beds are considerably contorted and broken at the bend, just north of a winter road across the claims, where the road passes off rock and into low ground on the east.

Surface development has exposed a number of quartz veins and three pyritic replacement zones.

The principal quartz vein is on lot 21, 200 feet south of the winter road, and is exposed for 100 feet in a deep trench with a large open pit at the south end. It strikes north 15 degrees west and dips 50 to 75 degrees east. In the open pit at the south end, however, the angle of dip decreases to 25 degrees. The quartz pinches and swells, attaining a maximum width of 5 feet, in altered andesitic lava in part converted to black mica schist. The quartz is sparingly mineralized with coarse pyrite and lesser amounts of chalcopyrite, sphalerite, and galena. There are a few microscopic specks of at least two undetermined minerals, one grey and one white. The quartz is coarsely crystalline and white to watery and contains a few small pockets of pink albite. A picked sample with much more sulphide than the average, and said by one of the original owners to represent the richest material they had encountered, assayed 0·25 ounce gold and 7·83 ounces silver a ton.

Three hundred feet east, just south of the road, a prospect shaft has been sunk 40 feet on several small veins of quartz in banded, highly altered strata of the conglomeratic beds. There is little to be seen on the surface and the shaft was full of water when visited. Quartz on the dump carries much pyrite.

Four hundred feet west of the open pit several trenches expose lenticular quartz veins that strike northwest and dip steeply southwest in greenstone and mica schist. One vein of white quartz has been followed for 95 feet, and ranges from a few inches to 4·5 feet wide. It is mineralized with pyrite and a little chalcopyrite. Two other smaller veins nearby lie alongside narrow lenses of coarsely crystalline calcite in schist, and their walls are in places pyritized and silicified.

To the northwest, 200 feet north of the road, one pyritic quartz vein in sheared andesite has been followed for 150 feet by a trench and is up to 3 feet wide.

At two places 1,150 feet apart, on lots 20 and 21, at the contact between sedimentary and volcanic rocks, the strata are converted to pale grey quartz-sericite schists and are heavily impregnated with finely crystalline pyrite and some pyrrhotite across widths of 1 to 6 feet. In a pit at the north edge of greywacke outcrops 600 feet north of the road, on lot 21, schist is heavily impregnated with pyrite and pyrrhotite and contains small quartz-tourmaline veins across a width of 5 or 6 feet.

MALROBIC MINES, LIMITED

Malrobic Mines, Limited, holds the north halves of lots 11 to 14, inclusive, and all of lots 15 to 17, inclusive, in range V, Malartic township. In addition, the company has, or had, an interest in lots 6 to 9, range V. Development work on these claims consists of considerable surface trenching, several thousand feet of diamond drilling at intervals along the strike of the main showings, and a shaft to 250 feet, with approximately 600 feet of lateral exploration on the 125- and 250-foot levels. No commercial ore-bodies were developed, and work was stopped in December 1928. When the property was visited in 1935 the shaft was flooded to the collar. In 1934 it had been pumped out and sampled.

The claims are crossed diagonally from northwest to southeast by the northern band, approximately 2,400 feet thick, of the Blake River group of volcanics. This is underlain on the north by greywacke of the Kewagama group and overlain on the south by greywacke of the Cadillac group. The Blake River group includes, near the east side of lot 17, a band of greywacke and conglomerate 200 feet thick.

A swarm of feldspar porphyry dykes intrudes the greywacke of the Kewagama group, but none was observed cutting the Blake River or Cadillac groups. The dykes range in thickness from a few inches to 100 feet; as for the most part they are intruded parallel to the strike and, so far as known, the dip of the bedding, they might more properly be termed sills. They are accompanied by one or two, small, later, crosscutting dykes of biotite lamprophyre.

Transverse quartz veins a few inches thick, which extend from wall to wall in the smaller dykes, are a characteristic feature of the feldspar porphyry dykes; there is a remarkable display of these veins in the 100-foot dyke exposed near the north side of lot 15 (*See* Plate II B). These quartz veins appear for the most part to be barren; the greywacke adjoining small quartz veins at the west end of the exposures is mineralized with arsenopyrite and pyrrhotite.

Most of the development work was done on a sheared, carbonatized zone near the southern side of the Blake River group, and the shaft was put down on this zone just north of the power line in lot 16. The zone, at the time of the visit, was poorly exposed in a series of trenches and pits over a length of 300 feet; it ranges in width from 18 to 33 feet, with the boundaries indefinite because of the gradational change from strongly carbonatized to normal greenstone. The zone strikes 15 degrees south of east at a small angle across the bedding, which strikes 25 degrees south of east. Seven hundred feet east on the strike of the main showing a similar carbonatized zone is exposed in a pit. The intervening, drift-covered ground has been diamond drilled, but the writers have no knowledge of the results obtained. Also, 1,700 feet west of the shaft along the strike of the main showing, a carbonate zone is exposed on the south side of a large outcrop of greenstone; this carbonate zone may or may not be continuous with the main showing.

The carbonatized rock is cut by numerous irregular quartz veins, mostly less than 2 inches wide but with some swellings up to 4 inches wide; the veins carry some tourmaline, and are crossed by veinlets of coarsely

crystalline, ankeritic carbonate. Pyrite is sparingly disseminated through the quartz and the intervening carbonatized greenstone schist, but is most abundant along the walls of the veins. A little pyrrhotite was noted in one or two places, and small, brilliant plates of specularite are abundant on some cleavage faces. No information as to assays was obtained.

A sketch map of the underground workings was kindly supplied by Mr. Alan Colby of the company. According to this map, work on the 125-foot level consisted of a drift in carbonatized greenstone, 140 feet eastward and 25 feet westward from the two-compartment shaft. On the 250-foot level a crosscut was driven 360 feet northward and at least 85 feet southward from the shaft. To the north, this crosscut encountered two or three dykes of feldspar porphyry, presumably in greywacke; the remainder was in schistose to massive greenstone. It is reported that little encouragement was obtained below a depth of 80 feet in the shaft.

A second carbonatized zone, 30 to 60 feet wide, follows the contact between the Blake River group and the Kewagama group. The rocks there grade from greywacke on the north into fine-grained, tuffaceous greywacke, and thence to fine-grained, grey tuff on the south. No definite contact can be located, especially as the relations are obscured by carbonatization. The zone is identical in location and character with the one explored more extensively on the Thompson Malartic property to the west; a similar zone crops out along this contact on Panamint property to the east.

Some diamond drilling and a little surface work was done in lot 9, range V, on a sheared, pyritized zone in greenstone, near the contact between the Blake River and Cadillac groups. The zone, as exposed in a pit just south of the power line, is at least 15 feet wide; the greenstones are sheared to soft, chlorite schists, heavily mineralized with carbonate and finely divided pyrite.

MARITIME CADILLAC GOLD MINES, LIMITED

This company was incorporated in 1936 to acquire the property of Maritime Cadillac Syndicate. Originally staked by the late Joe Lewis, the sixteen claims include some of the oldest mining claims in Cadillac township. They lie south and southwest of Lapa Cadillac Gold Mines. Before 1937 a great deal of trenching and some test pitting had been done to prospect the claims and to explore several quartz veins. A campaign of diamond drilling, largely in low and heavily drift-covered ground, was started in November 1936 and continued during the winter. Late in 1937 a shaft was sunk to 160 feet and a limited amount of lateral work was done on one level during 1938.

The claims are underlain by greywacke of the Kewagama group, by schists and greenstone of the Cadillac belt, and by greywacke and conglomerate of the Cadillac group.

Greywacke of the Kewagama group is exposed on high, timbered ground in the western part of the property. Although highly contorted in places, the strata strike northwest on the average and dip close to vertical. In a few places the sedimentary rocks show crossbedding. They are in part converted to mica schist and amphibolite. On the extreme west they are

intruded by the Heva Lake granite body, and between the granite body and the Cadillac belt to the east by many acidic dykes, undoubtedly offshoots of the main mass. In a general way these dykes follow the bedding of the greywacke, but they have a decided tendency toward irregular outlines that in detail causes crosscutting relationships. Granitic aplite and grey albite porphyry are the common types.

The Cadillac belt is not well exposed, for most of it underlies a swamp that crosses the eastern part of the claims from north to south. However, there are about a dozen outcrops near and north of the township centre line. All the rocks are highly altered. Andesitic lavas are most abundant, but there is some basalt, and bedded tuffs were noted in several places. Knowledge of the Cadillac belt elsewhere suggests that major intercalations of sedimentary rocks may be expected. Some phases of andesite are holocrystalline and resemble diorite, and there is one irregular intrusive body of quartz diabase on the centre line 600 feet east of the road. In many places the strata are heavily sheared and intensely drag-folded. One well-exposed, small syncline near the road and 400 feet north of the centre line plunges 65 degrees to the east, but other drag-folds were observed to plunge westward. For about 2,300 feet south of the centre line the claims cover the full width of the Cadillac belt. Its maximum width may be about 2,400 feet, but neither contact is exposed. North of the centre line the western part of the belt is included for a strike length of about 1,700 feet.

Greywacke and conglomerate of the Cadillac group are exposed in the southwestern corner of the property. The strata are intricately contorted. Conglomerate occurs principally near the base of the series as well-defined beds up to 25 feet thick, and also as beds in which there are only a few scattered pebbles in normal greywacke. The degree of contortion decreases toward the south boundary of the property, and the beds finally strike uniformly east of south. Some interbedding of volcanic and sedimentary rocks may be expected near the Cadillac belt, for 25 feet of schistose and amphibolitized tuff was noted between conglomerate and greywacke at one place.

With the possible exception of a narrow band of altered, grey, felsitic rock that may be quartz albitite or a rhyolitic flow, no dykes were noted in the Cadillac group on the property.

The claims cover part of one of the structurally most complex areas in the district, and outcrops are much too few to permit of anything like a detailed solution. The Heva Lake granite body has probably acted as a buttress around and against which the older strata have been bent and faulted. From the meagre data available it may be safely assumed that the Cadillac belt is intricately contorted and broken by many faults. Unfortunately, this key horizon of the area is very poorly exposed on the claims, and its location as shown on Map 575A has had to be largely inferred from a study of the adjoining strata. A detailed solution of the structure could only be expected after much underground work has been done. Only if valuable mineral deposits are encountered at an early stage can such work be justified. The early establishment of trustworthy horizons along the belt will be of paramount importance, for the mineral deposits will undoubtedly be controlled by the structure. Such horizons might be the

edges of the belt, where sedimentary beds of the Kewagama and Cadillac groups appear; distinctive horizons of volcanic or sedimentary rocks in the belt; or, possibly, major shear zones in the belt, for it is possible that major shears were developed along the belt before the complex contortion of the strata took place.

The writers' conception that the contortion was caused by force couples acting in such a way as to move strata on the north eastward relative to those on the south, more nearly horizontally than vertically, has already been emphasized, and, if accepted, should serve as the theoretical basis for interpretation of detailed information.

It is well known that in other parts of Cadillac township cross faults displace the Cadillac belt and the gold-bearing veins in it. One inferred, right hand fault, striking north 60 degrees east in the southeast corner of the property, is shown on Map 575A. This fault was not observed, but is suggested by the regional mapping, and by the fact that a parallel fault, with important but undetermined right hand displacement, was discovered in 1936 in the Cadillac group a short distance to the south. Other similar faults might be expected on the property.

A number of quartz veins have been discovered. West of the road and 250 feet north of the centre line of the township a small, northwesterly striking vein is exposed in greywacke of the Cadillac group for 40 feet from the edge of the Cadillac belt. It carries some sulphides, principally pyrite. South of the centre line there are veins and irregular masses of quartz both east and west of the road in the Kewagama group rocks. They are barren or are sparsely mineralized with sulphides, and some carry tourmaline. Most of them are close to or in dykes of feldspar porphyry. A few quartz veins have been found in the Cadillac belt.

The principal surface showing is in the southeast corner of the property, within the Cadillac group. At the west side of high ground, contorted greywacke and pebble conglomerate are silicified and cut by many irregular quartz veins. In a shallow pit and trench 15 feet of quartz and greywacke are sporadically mineralized with arsenopyrite, pyrite, chalcopyrite, and galena, and contain at least a few specks of native gold. An exposure of 5 feet of quartz 50 feet south may indicate that the general strike of the zone of mineralization is slightly west of south, but there is no single, well-defined vein. A few feet of quartz and greywacke are exposed 25 feet east of the southern showing, and greywacke and conglomerate for 35 feet east of the shallow pit are cut by many quartz veins. The northerly and southerly extensions of this wide, quartz-bearing zone are drift covered. The company reports interesting gold assays from the main showing and has recently probed it by diamond drilling.

The known southeast end of the Dunlop Consolidated No. 1 vein is only a few tens of feet from the Maritime Cadillac boundary, and the vein's strike is toward the property. The Dunlop No. 2 vein also strikes toward Maritime ground. These veins are in the Cadillac belt. As it is established that the principal mineral deposits for several miles westward lie in the belt, it is evident that the full value of the Maritime Cadillac property cannot be established until the drift-covered area under which

the belt lies has been explored. The diamond drilling in 1937 probed the eastern part of the greenstone belt south of the centre line, and is reported to have indicated gold in association with one or more albitite dykes. The underground work was terminated before the interesting drill intersections had been explored.

MERVYN MALARTIC GOLD MINES, LIMITED

(Afton Mines, Limited)

Afton Mines, Limited, optioned lots 4 to 11, range IV, Malartic township, in 1936 and formed the subsidiary Mervyn Malartic Company in March 1937, to prospect the property. Mr. Heber Bambrick was in charge of operations in 1936 and in September had started a campaign of diamond drilling. One hole had been drilled on lot 4, 2,800 feet east of the Dempsey Cadillac shaft, when the writers last visited the property in September.

Outcrops are limited principally to a narrow ridge that trends south of east across the property. All exposures are sedimentary rocks of the Cadillac group—greywacke, arkosic quartzite, and conglomerate—that strike uniformly about north 70 degrees west and dip very steeply. These rocks are cut, in places, by small quartz veins, most of which strike more nearly due east than the sedimentary strata. The drill hole was put down under a pronounced depression between two ridges. It cut massive greywacke, quartzite, and some conglomerate, and, in three places, narrow zones of shearing. No important mineral deposit was revealed. A second hole was drilled about 3,000 feet to the northeast, in a large, drift-covered area.

PANAMINT GOLD SYNDICATE

(Panamint Malartic Mines, Limited)

This syndicate's holdings are reported to include lots 20 to 25, range V, Malartic township. The new Malartic highway passes a short distance south of the claims and the transmission line crosses them. A small crew of men were engaged in surface development in 1936.

Malartic volcanic rocks underlie the northeastern half of the property. They are cut by many dykes of feldspar porphyry and by several northeasterly trending dykes of quartz diabase and lamprophyre. A number of small, silicified zones and quartz veins, of no apparent value, were noted in the volcanic rocks. In outcrops on lots 23 to 25 the volcanic and sedimentary rocks to the south are broken by several northeasterly trending faults of small displacement. Several of these faults are filled by quartz and silicified, brecciated rock.

Southeast of the Malartic group is a width of about 2,300 feet of greywacke of the Kewagama group, largely drift covered. On lots 24 and 25 beds of conglomerate occur at the north contact of the sedimentary group and are interbedded with volcanic rocks. On the southern parts of lots 21 and 22 the greywacke is cut by many small dykes of feldspar porphyry and by a few, highly altered basic dykes. A number of quartz veins and

silicified zones, in greywacke and in porphyry, have been uncovered there, particularly within 400 feet of the south contact of the sedimentary rocks. They carry variable, small proportions of pyrite, pyrrhotite, tourmaline, and ankerite.

On the southwest, in lots 21 and 22, the Kewagama sedimentary rocks pass gradationally into volcanic rocks of the Blake River group through a transition zone, up to 50 or 60 feet wide, of siliceous, grey to greenish grey beds that could be classified with either group. Exposures and trenches along the contact zone have shown that, for a length of 1,050 feet, the rocks in and southwest of the transition zone are heavily carbonatized for widths of 25 to about 65 feet. The carbonate zone weathers rusty, due to the iron content of the ankeritic carbonate and to the presence of pyrite and pyrrhotite. There is little quartz in the carbonate zone, but small quartz veins are very abundant just to the north, in altered, and in places slightly carbonatized, sedimentary rocks. The sulphides are disseminated through carbonate or occur as small veins and lenses, particularly in uncarbonatized layers and lenses of chlorite schist. A sample of carbonatized rock as free as possible of sulphides was taken and assayed 0·02 ounce gold a ton. The westernmost exposure of the carbonate zone is some 75 feet too far north to connect along the normal strike with eastern exposures. The zone is either faulted or takes a sharp bend in strike under a small, drift-covered area.

The carbonate zone is identical in character and occurs at the same horizon as the carbonate zone at the Malrobic and Thompson Malartic properties, 6,500 feet and 2 miles northwest, respectively. Between these three places the contact zone at which the carbonatization occurs is obscured by drift.

The volcanic rocks southwest of the zone at Panamint are a mixture of andesitic to dacitic lavas and agglomerate with some small exposures of dioritic material that may be intrusive.

PAN-CANADIAN GOLD MINES, LIMITED

(Mines Operating Corporation)

Pan-Canadian Gold Mines is a holding and exploration company. Mines Operating Corporation was formed in May 1936 to develop the parent company's property of some 2,400 acres in eastern Cadillac township. J. W. Davis staked or acquired most of the ground in 1934 and 1935, for Pan-Canadian. Trenching and sampling done in 1934 led in 1935 to diamond drilling near the present No. 1 shaft, and a dozen holes were put down before the shaft was started. Camp buildings were erected late in the year. In July 1936 Mr. Davis and associates, while prospecting along the north contact of the Cadillac belt 4,000 feet northwest of the shaft, uncovered an unusually rich gold-quartz vein, which was soon stripped for 100 feet. After diamond drilling from the surface, a shaft was sunk in 1937 and levels developed at 150 and 275 feet. An experimental mill that proved unsatisfactory was converted to a 50-ton amalgamation unit early in 1938. No work has been done at the No. 1 shaft since the discovery of No. 2 vein.

The property covers the Cadillac belt for 3 miles northwestward from Malartic township. A new road to the property connects with the Malartic highway south of Heva River and electric power is provided by a branch from the transmission line 2 miles to the northeast. Heva River flows through the western part of the property.

The Cadillac belt of the Blake River group trends northwesterly across the property. It varies in thickness from 500 to 1,500 feet and consists predominantly of altered andesitic lavas with interbeds of tuff and greywacke. On the north the volcanic rocks are overlain conformably by conglomerate and greywacke of the Cadillac group, and to the south is greywacke of the Kewagama group. The strata are nearly vertical and the schistosity is parallel to the bedding except in areas of contortion. Along and southeast of Heva River the rocks are bent by a sharp drag-fold, so that a nose of the Cadillac belt projects eastward to the Dempsey Cadillac boundary. In this area the beds, and the schistosity, strike nearly due east. The plunge of the drag-fold is not known, although it is probably very steep. In all likelihood the major structure is greatly complicated, in detail, by contortion and faulting, particularly around the noses of the fold and in the Cadillac group south of the drag-fold.

Most of the rocks are somewhat schistose. Two major shear zones are known. One is probably continuous along the southern side of the Cadillac belt for 1½ miles northwest of the township line. It is exposed or has been cut by drill holes at several places in this distance. As described in detail in the section on structure, similar intense shearing is known to exist at many places in the belt all across the area, and is assumed to be one of the major structural features of the region. A trench near the Dempsey Cadillac-Pan-Canadian boundary at the north contact of the easterly nose of the drag-fold exposes 40 feet of soft chlorite schist between greenstone and greywacke. Whether this shear, which presumably must be due to faulting, is folded around the nose and crosscuts the belt to connect with the above mentioned shear zone at the south side of the belt, or whether the two are separate, remains to be proved.

The intrusives on the property include a few sill-like bodies of diorite in the Cadillac belt, small, basic dykes in the Kewagama group, and acidic dykes in both groups. No intrusives were found in the Cadillac group. The largest acidic intrusives cut the easterly nose of the Cadillac belt in the Heva River drag-fold and extend westward along the belt. The bodies are exposed for widths up to 100 feet, and are sill-like to exceedingly irregular in outline. The rock is sheared albite porphyry with phenocrysts up to 3 mm. in diameter and with considerable quartz in the groundmass. Finely divided sericite and biotite impart a grey or brown hue, depending on which is predominant. The other acidic intrusives are to the south, along the southern side of the Cadillac belt and in the Kewagama group. Dykes in the sheared volcanics near No. 1 shaft are small, lenticular, fine-grained, grey albitites. Dykes of albite porphyry and hornblende-albite porphyry, with phenocrysts to ½ inch diameter, are exposed to the south in greywacke. Some of these are exceptionally rich in pyrite, as crystals that attain diameters of ¼ inch.

No. 1 shaft is near the south side of the Cadillac belt, 1,750 feet west of Malartic township. A narrow alder swamp, south of the shaft, covers

the south contact of the belt. A few exposures and several trenches along the north side of the swamp show that for a length of 1,300 feet the volcanic rocks are in large part converted to fissile, green, chlorite schist, and are intruded by small lenticular dykes of grey albitite or albite porphyry (*See* Plate V). Furthermore, widths of 5 to 20 feet are carbonatized and albitized to a grey, hard, banded, rusty weathering material. There are, also, several lenticular, white to watery quartz veins. Minor Z-shaped drag-folds are fairly common. The rocks are most intensely mineralized towards the east end of the showings, where the strike of the schistosity suddenly changes from southeast to south 75 degrees east. Mr. Davis and associates obtained gold by panning material from some of the trenches, and report that grab and channel samples returned encouraging assays across widths up to 15 feet, with a few high assays.

At the west end of the workings there are several exposures of amphibolitic diorite rich in magnetite and in places mineralized with pyrite and arsenopyrite. At one place the diorite contact is exposed and the adjoining schists are charged with small crystals of magnetite. The intrusive rock consists essentially of albite and hornblende. Narrow widths of similar rock are exposed at several places to the east, on the north side of the mineralized zone.

The albitized schist consists of interlocking grains of albite and a little quartz with varying proportions of biotite, chlorite, and carbonate. Vein-like streaks and irregular areas of albite have formed by replacement. Tourmaline is present in some specimens in nests or disseminated through the rock, and magnetite forms up to 10 per cent of some thin sections. In addition to pyrite there is pyrrhotite, a little chalcopyrite, and arsenopyrite, and a little molybdenite on some of the sheared surfaces. Gold was observed in quartz and pyrite, as rare grains visible only under the microscope. All gradations exist between green chlorite schist, with or without pyrite, and grey to brownish albite schist.

In 1935 twelve drill holes were put down across the mineralized zone. Two went sufficiently far south to cut greywacke of the Kewagama group. At the surface the gold-bearing zone lies about 200 feet north of the contact. The drill cores and assay plans supplied by the company indicate a wide distribution of gold in all types of rock encountered—chlorite schist, albitized schist, porphyry, and quartz. The most consistently encouraging results were obtained in the eastern half of the area drilled, for a length of about 600 feet, but low assays are recorded in two holes to the west, giving a total length of 1,000 feet with the east end open. The best section in the easterly hole averaged $3.80 a ton across a true width of 22 feet, with assays in this width ranging from $1.40 to $6.30. The hole 100 feet west returned an average of $1.50 across a true width of about 37 feet in a correlative section. One foot of quartz 20 feet to the south returned $13.65 a ton. Similar results, with low assays across good widths and occasional high assays across widths up to 5 feet were obtained for 500 feet to the west. On the whole, values are shown at intervals in a zone some 250 feet wide with no well-defined walls.

Four thousand feet northwest the southwest contact of the Cadillac belt is marked by a pronounced valley 75 to 100 feet wide in which are a few exposures of rusty weathering schist. Lenticular bodies of porphyry

intrude greenstone and greywacke on the south wall of the depression. In 1935 Dubuisson Gold Mines, holding the ground under option from Pan-Canadian, drilled several holes across the valley. The drilling proved that a strong shear zone underlies the low ground and encountered pyritized schist, several quartz veins, and some small bodies of porphyry. As gold in important amount was not found, the option was dropped.

No. 2 vein, discovered in 1936, is 4,000 feet northwest of No. 1 shaft. When examined in September 1936 it was exposed for a length of 105 feet and had been followed some 25 or 30 feet farther west in a trench that was flooded. The vein strikes north 60 degrees west in conglomerate and greenstone, crossing the north contact of the Cadillac belt at an angle of 15 degrees. It is remarkably lenticular and occupies an unusually straight fissure, the walls of which are corrugated and grooved in such a way as to indicate that the south wall was thrust upward relative to the north. The maximum width of quartz exposed is 4 feet and the vein becomes smaller to the east and finally pinches out in conglomerate. A number of small branch veins occupy fractures in the conglomerate, and some of these carry gold.

The quartz is white to smoky grey and is intensely fractured. Thin partings of schistose country rock in the quartz, particularly near the walls, and seams of sulphides, impart a banded appearance that is accentuated by variations in colour of the quartz. The metallic minerals are arsenopyrite, pyrite, sphalerite, pyrrhotite, and chalcopyrite, all in very small amount except arsenopyrite. Dark-coloured native gold is plentifully distributed through the vein, rarely in massive quartz, generally along seams and fractures that carry arsenopyrite. The arsenopyrite is in small, wedge-shaped crystals and most of the gold observed under the microscope is in or alongside the crystals. Sericite is abundant in the wall-rock and along seams and fractures in the quartz. The gold is fine grained, usually in specks the size of a pin head or less. Only a little tourmaline was found in specimens examined by the writers.

During the summer of 1936 Noranda Mines channel sampled the vein at intervals of about 5 feet for a length of 105 feet. The reported result was an average of 1·04 ounces gold a ton across 18 inches.

Drift covers the westward extension of the vein, but trenches have been put down at wide intervals along the strike for about 1,100 feet. Several of these showed lenticular quartz similar to that of the vein, so there is good reason to believe that the known length of the vein may be materially increased as development proceeds.

In the autumn of 1937 underground work on the two levels showed the vein persisting as on the surface. It dips about 70 degrees southward and the intersection of the vein with the conglomerate-greenstone contact rakes east at about 60 degrees. Average widths of quartz are greatest in the conglomerate and the management reports that gold values are better there also, so that the principal ore shoot, for 70 feet or more east of the greenstone contact, also rakes at about 60 degrees to the east. West of the contact the vein had been traced for 275 feet on each level in greenstone. It is exceedingly lenticular, and on the whole the gold content is disappointing, but at least one short shoot of ore, raking east, is indicated. A very small, lenticular quartz vein that contains some gold was intersected on both levels 10 feet south of the main vein.

In the autumn of 1937 another small, auriferous quartz vein was discovered in conglomerate just north of the greenstone contact and 1,500 feet northwest of No. 2 shaft. Seven thousand feet farther northwest, on the north side of Heva River, the company has erected a small camp and has done much surface work along and north of the greenstone belt without disclosing anything of economic importance.

PAQUETTE MALARTIC MINES, LIMITED

This company controls a large block of claims in ranges II and III, Malartic township, west of the highway and including the southern halves of lots 21 to 24, range III. Grover Daly Mines, Limited, did considerable surface work and a little drilling at the latter place several years ago. Most of the work was done along a base line running north 65 degrees west. Trenches were made at small intervals for 2,800 feet along a narrow zone in which many small quartz veins roughly parallel to the zone occur in fine-grained greywacke. The base line is along the strike of the strata, which dip 75 to 80 degrees north. The quartz veins, which occur across widths of a few feet, are small and discontinuous, rarely over a foot wide. With them are considerable amounts of finely crystalline arsenopyrite, principally in the walls of the small veins. Some tourmaline was noted. A grab sample of quartz and greywacke, well mineralized with arsenopyrite, was taken and assayed 0·14 ounce silver and 0·4 ounce gold a ton.

Conglomerate outcrops 200 feet south of the base line and a 25-foot bed of arkosic quartzite is exposed 600 feet north.

PARTANEN MALARTIC GOLD MINE, LIMITED

This company owns lots 10 to 15, range I, lots 12 to 15, range II, and the south halves of lots 8 to 11, range II, Malartic township. Work on the property was done at least as early as 1926, when John Knox did some trenching in lots 11 to 14, range II. After that more work was done by Precambrian Holdings, Limited, and in 1934 drilling was done by Read-Authier Mine and by Ascot Gold Mines. The present company was formed in November 1936, acquiring the property from John Partanen and associates. The camp buildings are on lot 11 on the old Malartic road that leads to Canadian Malartic mine.

The lots in range I are underlain by greywacke of the Kewagama group, cut, particularly in the southern 1,500 feet, by bodies of feldspar porphyry and albite granite. Quartz similar to that at the old Cartier Malartic workings to the east occurs with the porphyry, but no intensive development of it has been undertaken.

Principal interest attaches to the holdings in range II. The average strike of the strata there is north 60 degrees west. The Kewagama group is bordered on the north by 3,300 feet of schists and volcanic rocks of the Cadillac belt. The south contact of the belt is on the property for 6,000 feet; the north contact, with greywacke of the Cadillac group, for about 4,000 feet. The only exposures of the Cadillac group are a few along the

contact. There are moderately good exposures of greenstone, diorite, and tuff in the Cadillac belt near the north contact, and a very few small exposures along the south one, the rest of the belt underlying a large swamp. The Kewagama sedimentary rocks are exposed on high, timbered ground that drops off rapidly to the swamp on the northeast approximately at the contact of the Cadillac belt. The old road follows the edge of the high ground across the property, and the camp buildings on lot 11 are just southwest of the contact of the Cadillac belt.

Scattered outcrops indicate that a number of dykes and irregular bodies of grey to pink feldspar porphyry and albite granite have been injected along the contact zone between the Kewagama group and the Cadillac belt. These intrusives extend 300 to 400 feet southwest into the sedimentary rocks. Drilling has shown that they also occur in the volcanic rocks immediately northeast of the contact, and that, in several places, the rocks of the contact zone are intensely sheared to mica and chlorite schists. The probability is that a major shear zone approximately marks the contact, and that the intrusions have risen along and near this zone. The principal mineral showings are very close to the contact. On lot 13 several strippings show greywacke intruded by porphyry and granitic dykes. At one stripping native gold is visible as small, irregular pellets on a fracture in rusty, altered greywacke a few feet northeast of a dyke of porphyry. The greywacke is altered to a mixture of albite, ankerite, biotite, chlorite, and apatite, and is laminated to schistose. It is cut by quartz veins roughly parallel to the bedding, is replaced, in places, by lenses of ankerite, and carries much fine-grained pyrite. Some of the quartz, which is white and coarsely granular, contains small pockets and streaks of ankerite and galena. A width of about 40 feet of highly altered and mineralized greywacke is exposed where the native gold occurs. Two hundred feet southeast a width of 6 feet of white quartz sparingly mineralized with galena is exposed in a trench at the south contact of pyritic porphyry that is at least 25 feet wide. These showings, and others of quartz and pyrite in porphyry and greywacke, are 2,000 feet southeast of the camp buildings. Fifteen hundred and 1,800 feet northwest of the building there are two other exposures of porphyry that cut greywacke. The first shows 75 by 45 feet of porphyry that is cut by transverse fissure veins, up to 18 inches wide, of white quartz that carries tourmaline and pyrite. These veins and the porphyry are cut by a 2-foot biotite lamprophyre dyke which is in turn cut by tourmaline-free veins of bluish quartz, one 2 feet and two others each 6 inches wide. This is the clearest proof found in the area of two distinct periods of quartz injection. The earlier, white quartz is typical of that observed in the locality. The second trench shows a width of 10 to 12 feet of rusty weathering, pyritic, mica schist cut by quartz veins and intruded on the southwest by dykes of feldspar porphyry. One of the latter, 5 feet wide, is veined and replaced by white to watery quartz that carries moderate amounts of pyrite and galena.

Most of the diamond drilling has been done southeast of the camp, near the showing of gold. The writers have examined the core of only one hole (hole A), which was drilled from the northeast to pass beneath the exposure where the gold is visible. The rock cut is largely soft chlorite schist, typical of that found elsewhere along the sheared south contact of

the Cadillac belt. There are, however, four distinct intrusive bodies, one of albite granite and three of porphyry, the cores from which range in length from 3 to 30 feet. Two of the intrusive bodies show increasing silicification toward the south contact. The albite granite was cut for 50 feet at the collar.

It has been reported that important gold assays were obtained from other holes in this vicinity, and that low assays were obtained from hole A, apparently from mineralized schist between the intrusive bodies.

The northern part of the Cadillac belt is exposed in the northern halves of lots 11 to 15, at intervals over a considerable area in which the drift cover is not deep. The contact with the Cadillac group is apparently conformable and not sheared. Some old trenches on lots 11 and 12 show widths up to 10 feet of highly silicified rock, probably tuff, that contains much disseminated pyrite and pyrrhotite.

During 1937 and 1938 Partanen Malartic Mines did considerable diamond drilling on the property and thoroughly explored the surface. The writers are not familiar with the results of the work. Reports issued from time to time by the company say that gold values of interest were obtained by drilling in two principal sections near the south contact of the Cadillac belt. The gold is said to be associated with siliceous replacements of porphyry in both places, the first being 2,000 to 3,000 feet northwest of the east boundary of the property, that is, within the area probed by the 1934 drilling. The second section starts 4,000 feet northwest of the east boundary, near the camp buildings, and is reported to have been traced for a length of 366 feet. A generalized geological map kindly supplied by G. F. Flaherty, consulting geologist, shows that a wide zone of intense shearing has been traced most of the way across the property and lies near the south contact of the Blake River group. No plans for underground development have been announced up to the end of 1938.

QUEBEC GOLD MINING CORPORATION

(National Exploration and Holdings Company)

Quebec Gold Mining Corporation holds an interest, with Mr. M. K. Coffin of Amos and associates, in lots 45 to 51, inclusive, range I, Malartic township, and five adjoining claims to the south, in Fournière township, numbered A44100 to A44104. A mineral discovery was made on lots 46 and 47 in September 1926, and subsequently was developed by trenches, stripping, and some shallow pits by the now extinct National Exploration and Holdings Company. The property has lain idle for a number of years and the old workings are partly caved.

The northern band of the Blake River group crosses the south boundary of Malartic township on lots 47 and 48 and strikes north 55 degrees west. It is about 650 feet wide and consists of a variety of highly altered volcanic rocks, including andesitic to dacitic lavas, and possibly trachytic tuffs, and some intercalated sedimentary rocks. These rocks are now converted in large part to chlorite or mica-chlorite schist and phyllite, and, particularly

on the southeast and in Fournière township, to amphibolite or amphibole-rich phyllite. The southern part of the band is almost entirely drift covered, and exposures along the northern part are restricted largely to trenches and strippings.

The Blake River group is bordered conformably on the north by fine-grained sedimentary rocks of the Kewagama group, moderately well exposed on lots 45 to 49. The prevailing dip of these bedded rocks is about 70 degrees to the north and the schistosity in the volcanics has about the same attitude. To the south there are few outcrops of greywacke of the Cadillac group. The only intrusives are small bodies of grey, quartz-bearing albite porphyry in the volcanic rocks in a zone within 200 feet of the contact with the Kewagama group. There are only small, scattered exposures, but they indicate that the intrusives are fairly small and irregular in outline. They occur at least for a length of 2,000 feet along the volcanic belt, 1,600 feet in Malartic township and at least 400 feet in Fournière township. Thin sections show that the rock consists largely of albite, partly as phenocrysts up to 2 mm. in length, in a groundmass of average 0·1 mm. grain, with 10 to 15 per cent of quartz and minor amounts of chlorite, biotite, carbonates, apatites, and iron oxide. The rock is generally considerably fractured and is in places mineralized. The southern part of the Blake River group may be the locus of a fault, for the few outcrops found there are of highly schistose rocks and the low, swampy ground may have developed along such an easily eroded, intensely sheared zone.

The chief deposits are exposed on lots 46 and 47, Malartic township, in a series of trenches and strippings. These workings reveal the contact between volcanic rocks and the Kewagama group in several places, and show that there is a gradational passage between the two, with nondescript tuffaceous beds and, at one place, a body of grey, crushed, highly altered albite porphyry at the contact. A large stripping that crosses the line between lots 46 and 47 has exposed irregular quartz veins and masses, in a zone up to 15 feet across, in the altered volcanic rocks 40 feet south of their north contact. Narrow widths of quartz have been exposed in another stripping 10 to 60 feet east. The quartz is white to watery and associated with it are black tourmaline, arsenopyrite, calcite, and a little white mica. The arsenopyrite is mostly beautifully crystallized in striated prisms and twins, up to one-half inch long. Relatively coarse aggregates of albite crystals accompany some of the arsenopyrite and are believed to have formed during the same period of mineralization. Microscopic examination shows that the arsenopyrite is fractured and veined by calcite and quartz, and that there is a little pyrite and ilmenite present. Also, in the one polished section five small specks of native gold up to 0·005 mm. in diameter were observed, all in or on crystals of arsenopyrite. It has been reported to the writers that gold assays are rather erratic, but on the whole low, the highset being 0·63 ounce a ton. The mineralized zone lies just north of a porphyry intrusive. A pit in low, drift-covered ground at the south contact of this body, or a similar body nearby, 70 feet south of the east end of the quartz-arsenopyrite showing, reveals a zone 1 to 5 feet

wide in which porphyry has been intensely brecciated and recementd by black to dark brown tourmaline, besides being cut by quartz veins. No appreciable quantity of sulphide was noted.

A large pit on claim A44104, 1,150 feet south of the Malartic township line, and just south of the south contact of the Blake River group, exposes highly amphibolitized sedimentary rocks cut by veins of quartz and black tourmaline across a width of 15 feet. Tourmaline is particularly abundant, and there are small amounts of arsenopyrite. Both here, and in two exposures within 125 feet to the southeast, the altered greywacke is in part replaced by vein-like masses of tourmaline.

RAND MALARTIC MINES, LIMITED

Rand Malartic Mines, Limited, owns twelve claims, A51645 to A51656, inclusive, south of the highway in Fournière township and just east of East Malartic mines. Sladen Malartic Mines developed the property until March 1937 and then incorporated the new company, retaining a large interest. Gold was discovered on the property in 1936 and the discovery was at once developed at the surface and by drill holes. In 1937 and 1938 a large amount of drilling was done to explore the southern, drift-covered part of the property. Encouraging results were obtained and a shaft was commenced in August 1938, but sinking was temporarily suspended in September.

prominent hill is bordered on the south by a zone of intense shearing. The of the highway. The exposures on it are conglomerate, greywacke, and arkosic quartzite of the Cadillac group. The beds strike north 70 degrees west and dip 70 degrees or more to the north. On the south the hill drops abruptly to low wet ground in which, for about 1,000 feet, there are scattered exposures. Farther south is flat, wet swamp. The scattered exposures, many of them in old trenches, include chlorite schist, amphibolite, and serpentine of the Blake River group. Diorite intrudes serpentine in one place and there are many exposures of schistose to massive feldspar porphyry. Much of the amphibolite has developed at the expense of serpentine and chlorite schist where these rocks have been altered by the later acidic intrusives. The porphyries are all rich in albite and vary from grey, finely crystalline, schistose varieties that resemble sheared arkose to grey or brown, massive types more typical of Fournière township. The differences in appearance and degree of metamorphism suggest that there are intrusives of two ages, but under the mircoscope the schistose and massive varieties are seen to be similar in composition, except for an abundance of sericite in the former. Furthermore, drill cores show gradation from massive to schistose varieties. Unfortunately, no contacts between the two types were found at the surface.

Diamond drilling has shown that, as the topography suggests, the prominent hill is bordered on the south by a zone of intense shearing. The shear marks the north contact of the Blake River group (Cadillac belt), and similar shearing has been found at the same horizon on Malartic Goldfields ground, 2,800 feet to the east. From data obtained on adjoining

properties, and the presence of a few outcrops of greywacke in the southwest corner of the claims, it appears that the Cadillac belt is at least 2,000 feet wide and that the extreme southern part of the property is underlain by greywacke of the Kewagama group. The amount of intrusive rock that has been found in the exposed parts of the Cadillac belt is in itself suggestive of intense dislocation, for no intrusive rocks were observed in the massive rocks of the Cadillac group to the north.

White quartz, with small amounts of pyrite and tourmaline, has been uncovered in several places in porphyry and schist within the Cadillac belt. Gold has been panned from some of these showings, but the sampling that has been done has not given much encouragement. There are also small quartz veins in the conglomerate and greywacke to the north, particularly along the south face of the hill. The discovery on which the first drilling was done is 200 feet south of the edge of the hill and at the west side of claim A51648. A band of highly altered rock, some 20 feet wide, has been trenched at intervals for a length of 300 feet. The rock is dark grey to brownish grey and slightly schistose; it weathers buff to grey. Least altered phases consist chiefly of fine-grained albite, mostly untwinned and crowded with inclusions of carbonate, pyrite, apatite, and sericite. Fine-grained carbonate forms 10 to 15 per cent of the whole, and there are minor amounts of biotite, quartz, apatite, magnetite, and tourmaline. It seems almost certain that the albite has been introduced and is not original; in spite of the abundant inclusions, much of it is remarkably clear and fresh looking. The rock might be termed an albite phyllite; it may well have been sediment originally. Pyrite is liberally disseminated throughout, and there are rusty weathering, pale grey lenses of ferruginous carbonate with which are associated small amounts of bright green, chromiferous mica. Fine-grained arsenopyrite, in needle-like crystals, is sparingly developed in some places. The rock is cut by a multitude of small, white quartz veins, many of them flat-lying but all tortuous and discontinuous; few are over an inch wide. They carry a little pyrite, tourmaline, and small pellets of native gold; apparently gold is limited to the veins. In 54 inches along one trench twenty-one small specks of visible gold were counted.

Eight holes had been drilled across the mineralized zone when the property was examined. The first five were at intervals of 50 feet. They show that the albitic phyllite is bordered on the north and south by schist and sheared albite porphyry. The dip is steep to the north and the hanging-wall porphyry is about 40 feet wide. The foot-wall porphyry is much wider, but there are partings of schist in it. The deposit persists at least to a depth of 150 feet and for over 400 feet along the strike, with the west end open. Company officials report that no commercial assays were obtained from the core. Two short vertical holes were put down in the mineralized outcrop, where gold had been found in quartz stringers, and likewise returned no commercial assays. Several bulk samples from trenches are reported to have averaged $6.80 and $11.20 across widths of 5 and 6 feet. It is, therefore, questionable if values obtained from drill cores in a deposit of this type can be accepted as representative.

The diamond drilling campaign of 1937 and 1938 was conducted in the western part of the property and concentrated on probing through

swamp in the southern contact zone of the Cadillac belt. Reports issued from time to time by company officials state that a zone about 200 feet wide at the south side of the belt is sheared and intruded by porphyry and diorite. Encouraging assays are reported in a length of some 800 feet, from quartz veins and the silicified porphyry in which they lie, from chlorite schist, and from diorite. The favourable zone is said to be bordered on the south by greywacke, presumably the north edge of the Kewagama group.

RUBEC MINES, LIMITED

Rubec Mines owns ten surveyed claims, covering some 400 acres, in northeast Cadillac township. The property was staked 10 or more years ago. Up to 1936 considerable trenching had been done, principally on several beds of iron formation that cross the southern part of the group. In 1936 camp buildings were erected near the highway and twenty diamond drill holes had been put down by December. A number of astonishingly high assays were reported from holes 15 and 18. At the request of company officials the Ontario Securities Commission appointed Colin A. Campbell to investigate the situation; he was finally convinced that the reportedly rich samples had been salted. His check samples yielded no assay over 35 cents a ton, except for one in which foreign material was suspected. After December 1936 only a small amount of surface work was done at the property.

The claims are underlain by strata of the Cadillac group. Greywacke is most abundant; conglomerate is poorly exposed in a bed about 300 feet thick in the middle of the group; iron formation and beds of magnetite occur in the greywacke north and south of the conglomerate, more abundantly on the south, in Blocks 2 and 1. The strata strike east to south of east; the dips are vertical to steep south. Many of the exposures or iron formation show intense drag-folding and there are many minor cross faults. A few observations of gradation in grain size in the sedimentary rocks are interpreted to mean that the axis of a major syncline extends east and west through the middle of the property, about where the conglomerate occurs.

The writers were unable to visit the property with anyone familiar with the surface showings. Some of the many small veins in greywacke carry a little tourmaline and feldspar. Most of the trenching done prior to 1936 is in Block 2, where there are several horizons of iron formation and magnetite in greywacke. The bodies of iron formation are up to 40 feet wide and consist of banded magnetite, specularite, jasper, and siliceous greywacke. Much of the iron formation is intensely fractured; many of the fractures are filled with white quartz, and in places pyrite accompanies the quartz in considerable amount. The general experience in the district is that gold occurs locally in these quartzose and pyritic zones, but as yet no such deposit has been found to be of commercial importance. Quartz veins also occur in greywacke near the principal zone of iron formation. One on Block 2 is exposed at intervals for 270 feet and is up to 6 feet wide. It is very sparingly mineralized with pyrite.

Block 1, the southernmost claim, through which the highway passes, is almost completely drift covered. A drill hole put down a short distance

south of the highway passed through nearly 400 feet of dense, grey, albite porphyry, in part altered and silicified in much the same manner as the Deane-Cadillac body. There are small amounts of pyrite and pyrrhotite in the silicified rock. The hole was drilled at a 45-degree inclination and, judged by an adjoining hole, must have cut across the intrusive at an angle of at least 45 or 50 degrees to its strike, so the true width may be only a small part of the core length. It is the only intrusive known to the writers on the property. In view of its intense and presumably hydrothermal alteration, and the fact that similar sodic intrusives have been found near many of the gold-bearing deposits of the district, the locality may well merit some further investigation. Further details of the rock and of its possible structural significance have been given under "General Geology."

SLADEN MALARTIC MINES, LIMITED

Reference: O'Neill, J. J.: Quebec Bureau of Mines, Ann. Rept. 1934, pt. B, p. 65.

The property of Sladen Malartic Mines surrounds Canadian Malartic Gold Mines on the north, east, and west. It consists of twenty-six surveyed, and some unsurveyed, claims; the mine workings are in the eastern part, on M.L. 2110. The new highway passes a short distance north of the shaft and electric power is obtained from Northern Quebec Power Company. Denis Agar is mine manager and J. R. Johnston, geologist.

The company also holds a large interest in Rand Gold Mines, 2½ miles east of the mine, and owns a group of claims in Cadillac township east of Lapa Cadillac.

The original claims were staked in 1923 and 1924 by St. B. Sladen and H. S. Kennedy. Muskeg and heavy overburden made prospecting difficult, so that by 1928 very little work had been done, although developments at the adjoining Malartic Gold Mines were proceeding and adding interest to the area. Early in 1929, under the guidance of Dr. W. F. James, a first serious attempt was made to probe beneath the deep muskeg that covered the probable eastward continuation of a mineralized zone known to carry gold on the adjoining Malartic (now Canadian Malartic) property. The gold there had been found on the easterly trending contact zone between a stock of syenite porphyry on the north and greywacke on the south. A hand drill was devised by James, and holes were put down through the swamp to obtain about 6 inches of core from bedrock. The contact was thus established along the south side of claim A3978 and some gold was found.

Cessation of operations at Malartic mine in 1929 dampened enthusiasm for the area, and very little was done for 4 years. In 1933, following the increase in the price of gold, Canadian Malartic Gold Mines was organized and operations resumed at that property. The mineralized zone on Sladen Malartic ground lay close to the south boundary of the property and the company in August 1934 purchased an adjoining claim on that side—M.L. 2110—originally staked by Mr. Fred Davies. Diamond drilling proceeded from January to October 1935, and indicated two fairly low-grade ore shoots. A 2 months sampling option to a prominent mining company was dropped in October; other financial arrangements were made

and stock offered to the public in January 1936. In February camps were erected and with Andrew Walz acting as consultant, a shaft was sunk near the westernmost ore shoot to 200 feet, where the first level was established. Fifteen hundred feet of lateral work outlined a large ore-body with reported assays considerably higher than had been indicated by drilling. The shaft was then deepened to 538 feet and two new levels established at 350 feet and 500 feet. Following development at three horizons and additional diamond drilling at the east side of the property, a 250-ton mill was erected in 1937 and went into operation in January 1938.

Much of the company's ground is covered by swamp and deep drift, so that only an incomplete knowledge of the geology can be obtained from outcrops. However, the southern and greater part is underlain by greywacke of the Kewagama group, black to pale grey and well bedded in layers from a small fraction of an inch to about 2 feet thick. The dark varieties are argillaceous, the lighter members vary from impure arkose to impure quartzite. Many beds and groups of beds exhibit good gradations from distinctly granular bottoms to dense tops, the maximum grain size averaging about $\frac{1}{16}$ inch. West of Canadian Malartic mine a few beds carrying angular fragments up to 1 inch across were noted. All varieties are metamorphosed, varying from glittering mica and chlorite schists to massive, siliceous types with mica flakes rare or concentrated along bedding planes.

The general strike is from 5 to 25 degrees south of east, and is particularly uniform on the east near the mine workings. On the western claims, however, the regional trend is interrupted by considerable contortion and drag-folding. It is as yet impossible to solve completely the structure in this western area, but limited outcrops indicate a rather persistent series of S-shaped drag-folds such as would form when there is a regional tendency for beds in the north to move west relative to those on the south. Movements related to the intrusion of the many porphyry bodies have undoubtedly complicated the situation. In undisturbed areas the dip is steep to the north, rarely less than 70 degrees.

The Cadillac belt of greenstone crosses the northern part of the property. It is very poorly exposed, but includes pillowed andesite and other flows in various stages of alteration, including chlorite schist and amphibolite. O'Neill records some interbedded greywacke. Neither contact of the belt is exposed, but the minimum width is about 1,500 feet and it may be twice that. Recent drilling at the boundary between East Malartic Mines and Sladen Malartic has indicated a wide zone of schist in the Cadillac belt near its south side, altered and mineralized bodies of diorite in the schist, and massive serpentinized greenstone north of the sheared zones. A pronounced scarp trending south of east at the south side of exposures of pillow lavas suggests the presence of a fault or shear zone 2,500 feet north of the Sladen shaft.

There are no exposures in the extreme northeastern corner of the group, but in this place greywacke and conglomerate of the Cadillac group should border the greenstone belt.

A stock-like body of porphyritic albite granite, at least 2,000 feet by 1,100 feet at the surface, is poorly exposed along and near the Malartic township line, on either side of the highway. The rock is grey and carries phenocrysts of albite up to one inch long. Quartz is abundant in rounded phenocrysts and in the groundmass. There is a small proportion of microcline; biotite, chlorite, sericite, apatite, and black iron oxide are accessory. The granite can be seen to intrude lava at one place along the southern edge, but elsewhere the contact is drift covered. Several granitic dykes, probably offshoots of the main mass, cut the greenstone to the south; a dyke of quartz-feldspar porphyry, in greenstone 2,800 feet north of the Sladen shaft, is probably related to the granite in origin. This dyke carries albite and quartz phenocrysts up to 3 mm. in diameter and microscopic prisms of tourmaline.

The Kewagama group is cut by many dykes and irregular bodies of quartz syenite porphyry. The larger bodies are grey to brownish rocks with numerous phenocrysts of feldspar. Albite is most abundant, but there is some orthoclase, microcline, and microperthite. Quartz is always present, but the amount varies greatly, the rock grading, apparently, from quartz syenite to granite in this respect, but quartz phenocrysts are decidedly rare. White mica, biotite, apatite, and rutile are accessories, and pyrite and carbonate have been introduced. The texture is very variable. A large number of feldspar porphyry dykes are probably closely related in origin to the larger bodies. They have about the same composition as the larger bodies, the principal difference being in texture, for the feldspar phenocrysts are set in a very fine-grained groundmass of quartz and feldspar. These porphyritic dykes vary considerably in appearance and in degree of alteration, but the writers found no evidence on which to base a genetic or chronological subdivision. It seems more probable that the different varieties are, along with the major bodies, all derived from the same magmatic source.

Quite different to the above in appearance are a few, dense, porcelaneous, grey to pink dykes that cut the greywacke. One dyke 14½ feet wide is exposed near the southwest corner of M.L. 2110. It is cut by small quartz stringers and strikes due east. Similar dykes were noted in the western part of the property and they are fairly common at and southeast of Canadian Malartic mine. The Sladen dyke consists of a few phenocrysts of albite (An_3) in a dense groundmass of quartz and albite, with minor amounts of apatite, pyrite, and white mica. O'Neill classifies these dykes as aplite porphyry; they have previously been termed silexite and rhyolite porphyry. In this report they will be termed quartz albitite, as they closely resemble dykes of that rock in the Cadillac area.

There are a few, dark green, basic dykes on the claims. Some exposures of diorite and amphibolite in the Cadillac belt may represent dykes. Amphibolite dykes occur in the Kewagama group. Two dykes, 200 feet south of the Sladen shaft, are 20 inches wide, cut greywacke, and strike northwest. They are fine grained, and consist of about 50 per cent of hornblende and biotite in a dense groundmass of quartz and feldspar, with minor amounts of epidote, zoisite, apatite, and carbonate. Quartz-hornblende kersantite is the most applicable name.

As already noted, the strata strike south of east and dip vertically to steeply north except where affected by drag-folding. The property is on the south limb of a large syncline. The sedimentary rocks at the contact with the larger porphyry intrusions are contorted and folded to some extent.

There are probably many faults as yet unknown, for outcrops are scarce. There is a distinct possibility that a major zone of shearing and faulting trends south of east on the southern part of the Cadillac belt across the property. Drilling at the east boundary has intersected a wide zone of schist at the contact between Kewagama greywacke and greenstone to the north. Drilling along the south contact of the porphyry mass, on Sladen and Canadian Malartic ground, indicates a number of faults that strike east to south of east and, in part at least, dip steeply south and cut greywacke and porphyry. Similar faults are visible in the mine and will be referred to again. Such an easterly trending zone of faults may, with the adjoining contact of the porphyry, be the major structural control that established the trend of the mineralized zone from Canadian Malartic eastward across Sladen and into East Malartic ground. In the mine the south contact of the porphyry dips irregularly but steeply south. However, drilling seems to indicate that the contact may be expected to be a very uneven surface, and the strike correspondingly tortuous.

The porphyry and the greywacke are strongly fractured and, as will be shown in the description of mine workings, this fracturing has clearly exerted some control on the mineralizing solutions.

In spite of the fact that the company has done a great deal of well-planned surface work, and has had first class geological maps prepared, much remains to be learned about the mineral deposits, as a very large part of the property is heavily drift covered. On the southwestern claims quartz and pyrite have been found in association with several irregular, stock-like bodies of porphyry. Panning of some of these showings has shown the presence of gold, but no commercial assays have been obtained from samples. Farther north, both north and south of Malartic River, greywacke is cut by many porphyry dykes and is in places intricately drag-folded. In this area, bounded on the north by the Malartic township line, many quartz veins have been found in greywacke and porphyry, but no gold assays sufficiently high to encourage extensive development have been obtained. Besides pyrite and ferruginous carbonates, some of the veins carry galena, and the greywacke or porphyry adjoining them is commonly heavily pyritized.

Native gold has been found in quartz at the sheared southern contact of granite on claim A3973, 100 yards west of the highway and 950 feet south of Malartic township. The old workings are much caved and the writers noted only pyrite with the quartz. The contact trends a little north of west; intense fracturing in the granite dips about 60 degrees north and strikes roughly parallel to the contact. Some low gold assays have been obtained from quartz stringers in granite, near the southeast corner of the body, about 1,500 feet east of the above workings. Near the northwest corner of claim A3980, about 1,000 feet south of the granite contact, two old trenches expose a carbonatized and quartz-veined zone, up to

6 feet wide, in sheared and amphibolitized greenstone immediately south of a partly exposed porphyry dyke. The dyke and the mineralized zone strike about north 70 degrees west.

The mine shaft is near the northwest corner of M.L. 2110, in a wet swamp. There are a few outcrops of greywacke south of the shaft and several of them show quartz veins and silicified zones, with which are associated varying proportions of pyrite, galena, and chalcopyrite. Some old trenches in the swamp about 1,100 feet southwest of the shaft are reported to have uncovered a small, northeasterly striking quartz vein mineralized with pyrite, galena, sphalerite, and chalcopyrite, and carrying high gold values.

There are no outcrops of the principal ore-bearing zone on Sladen ground. All data concerning it have been obtained by diamond drilling and underground workings. The greywacke of the area is intruded by an easterly trending and roughly lozenge-shaped body of quartz syenite porphyry. At the west side of the property this body is about 1,000 feet wide, but it apparently narrows abruptly farther east. The two principal ore-bearing areas that have been found lie at the southern contact, which strikes irregularly 10 to 15 degrees south of east across the property.

The original drilling in 1935 indicated two principal ore-bodies. The western one, adjoining Canadian Malartic, was estimated by Mr. Walz, consulting engineer, to contain 95,000 tons of ore grading $8.40 a ton or 316,000 tons of ore grading $4.18 a ton. The eastern one, 1,200 feet from the Canadian Malartic boundary, was estimated to contain 60,000 tons of ore grading $6.45 a ton or 180,000 tons grading $3.75 a ton. The shaft was sunk midway between the two bodies and south of the ore zone.

The mine was examined in 1936 before the first level had been completed; in October 1937 it was revisited and some additional underground mapping was done. The writers are deeply indebted to J. R. Johnston, mine geologist, for additional geological maps and for much other information concerning the deposits.

Figure 8 shows, in generalized form, the main geological features of the mine. The shaft is sunk in greywacke that strikes a little south of east and dips vertically to steeply north. To the north the greywacke is intruded by the main mass of quartz syenite porphyry. The south contact dips to the south and in detail is very irregular. Developments at the 500-foot level indicate that the porphyry masses finger out irregularly in greywacke to the east. Besides porphyry and greywacke, and various altered phases of these, the only other rock encountered underground is highly altered lamprophyre. It occurs as northeasterly to northerly trending dykes a few inches wide, which dip to the east, generally at low angles, and follow tortuous paths. They are now quartz-mica schists, practically indistinguishable from normal schistose greywacke, but they definitely cut greywacke, porphyry, and silicified phases of these in the contact zones. With some of these dykes, and also elsewhere cutting porphyry and silicified rock, are small veins or dykes of pegmatitic feldspar, quartz, mica, and a few other minerals.

The major structural units of the mine are relatively simple, but in detail there are many complexities. Greywacke beds, away from the

immediate contact of the porphyry, strike nearly due east and dip vertically to steeply north. Only in a few places can bedding be surely distinguished underground, as the strata do not vary greatly in composition. It seems that freshly broken surfaces do not show stratification as well as those that have been exposed to the damp mine air for some time; perhaps older parts of the mine in greywacke should be re-cleaned at intervals and re-studied for additional structural data. At present it would appear that the greywacke acts as a massive structural unit in which bedding is of no great significance.

The south contact of the porphyry trends very irregularly south of east at a small angle across the strike of the greywacke and dips southward across the dip of the strata. The angle of dip varies greatly from practically vertical to as low as 10 or 15 degrees, but averages 70 degrees at the shaft and about 53 degrees at the west end of the mine. As previously noted, the porphyry mass apparently tongues out very irregularly on the east in greywacke. The third major structural factor is a fault, or fault zone, that persists through the mine at and south of the porphyry contact. The available evidence suggests that there is a single main fault, generally with an inch to several inches of gouge and crushed rock along it, accompanied by subsidiary, parallel or branching faults and shears. In addition, in many places the greywcake and the porphyry have been brecciated (*See* Plate VI). The brecciation, however, is commonly masked by later alteration and shows best on polished surfaces. Minor structures indicate that the main fault is a normal one; at least some of the movement is post-ore.

Besides the main fault zone and subsidiary faults related to it, there is a multitude of minor shears, fractures, and joints in the porphyry and greywacke. An attempt was made to map all these minor structures on the first level with a view to establishing the detailed structure of the ore deposits, but did not lead to important results. However, more extensive studies might yield results of value, for J. J. O'Neill, who examined the property in 1936 for the company, attaches considerable importance to this phase of the structural geology. It is certainly true that many of the minor shears and fractures in the second level, and elsewhere, have exerted some control on the localization of ore. Siliceous solutions have travelled along many of them, depositing quartz and silicifying the adjoining rock. The porphyry, even well away from any ore-body, is thus extensively altered from its normal grey to a pink or brownish colour, and in some places contains seams of feldspar, biotite, and quartz. Where the fractures are closely spaced, or the alteration particularly intense, the porphyry assumes a distinctive mottled appearance, due to darker, unaltered bodies remaining in lighter, altered phases. Within the western ore-body fractures and shears have guided the mineralizing solutions and to some extent determined the extent of silicification. But, to the writers, it seems probable that such control is of secondary importance, that the ore would have formed there whether or not the multitude of minor structures existed. With this view, the important structural features become the main fault-breccia zone through the mine, and the contact between porphyry and greywacke.

By the end of 1937 two principal ore-bodies had been found in the mine. One, at the extreme west end of the property, had been found on three levels and was being prepared for stoping above and below the first level. The other had been encountered on the 500-foot or third level, east of the shaft, and was not extensively developed.

The western ore-body is best exposed on the first level (200-foot level) for 200 feet east from the Canadian Malartic boundary. It is a wide and irregular mass of silicified greywacke and porphyry astride the contact of these two rocks, and north of or below the main fault zone (*See* Figure 8). The ore varies from dense, grey to yellowish, mottled, cherty, silicified greywacke and brecciated greywacke (*See* Plate VI) to white and bluish white, fine-grained quartz. The most siliceous varieties are markedly translucent (*See* Plate VII). From these two varieties there are all gradations to pyritic grey porphyry and relatively unaltered greywacke that also contains pyrite. The associated metallic minerals include pyrite, sphalerite, galena, chalcopyrite, native gold, and at least two tellurides. Haycock[1] has definitely identified sylvanite as the most abundant; the second, less abundant, is probably petzite. All the metallic minerals are very fine grained. Pyrite extends far beyond the boundaries of the ore and is least abundant in the most highly siliceous and richest phases. The other minerals occur along boundaries of quartz grains and, less commonly, along fractures in the quartz; in the latter case they are associated with very finely divided sericite. Chalcopyrite is a very minor constituent. Native gold, as tiny specks and rare, minute, isometric crystals, is principally in sylvanite and petzite or free in quartz. None was found in pyrite.

Much of the pyritic, silicified greywacke and porphyry is cut by bluish grey, translucent quartz veins that in places spread out irregularly to form large masses of quartz, which constitute the best ore in the mine. Pegmatitic veins of pink feldspar (albite), biotite, and a little quartz cut the siliceous ore. Small amounts of pale, honey-coloured garnet were observed on the wall of one such vein in association with quartz, pyrite, and chalcopyrite. The latest features are calcite seams that carry some pyrite and chalcopyrite. Unusual, but of no apparent commercial importance, are quartz veins carrying galena and pyrite that occur in the unaltered porphyry north of the ore-body. They are not known to carry important amounts of gold.

Within the ore-body itself the gold is rather erratically distributed. A general decrease in value toward the hanging-wall as the degree of silicification diminishes leaves irregular widths of non-commercial, relatively unaltered, pyritic greywacke below the main fault zone. The ore-body, as shown on Figure 8, has a maximum width of about 60 feet in a horizontal plane, but the boundaries are commercial so that the actual width mined will depend on the grade of ore desired and the mining method adopted. Nevertheless, there is a distinct, high-grade part along the foot-wall, where the limit against worthless porphyry is comparatively well defined along a series of fissures and sharp replacement boundaries. A body of highly siliceous ore there, from 7 to 25 feet wide, has an average gold

[1] Report of the Ore Dressing and Metallurgical Laboratories; Mineragraphic Laboratory, Dept. of Mines and Resources, Ottawa, Feb. 10, 1937.

content of well over one-half ounce a ton for its length of nearly 200 feet. Similar ore of better than average grade had been encountered in two sub-levels above, and one below, the first level. The second level (350-foot level), west end, has opened a wide zone of low-grade, silicified material with a few local enrichments, but drill holes put up and down from it are reported to have given more encouragement. The third level (500-foot level) was driven north of the foot-wall of the ore zone, in porphyry. Holes drilled south indicate gold in porphyry and greywacke, but are insufficient in number for a proper evaluation of this section.

The eastern ore-body on the third level (500-foot level) begins 350 feet east of the shaft. In plan it is an irregular, lozenge-shaped body with a maximum width, on the level, of 45 feet. Good commercial values have been secured for 100 feet at the west end, and the total length might be estimated as approaching 200 feet, with values low and erratic on the east. The ore is in greywacke and porphyry and differs from that at the west end of the mine in being less silicified. Indeed, in large part it is so little silicified that it is impossible, in most places, to tell by appearance where ore may end and waste rock begin. The ore lies at the east end of the main porphyry mass, where tongues of porphyry project eastward into greywacke, and for the most part is in a long projection of greywacke some 28 feet wide, which is bordered north and south by tongues of porphyry. Ore does not extend for any appreciable distance into the northern tongue of porphyry, but does continue across the southern body, as indicated in Figure 8. The porphyry is the normal grey to pink variety of the mine, cut by pegmatitic quartz veins and liberally sprinkled with pyrite. Black rutile is a common constituent of the veins. The greywacke is grey to brownish grey and, like the porphyry, is pyritic and cut by pegmatitic veins. Adjoining the contact with the north tongue of porphyry it is brecciated. A section of some of this material, reported to assay about $15 a ton, shows a fine-grained, highly altered, brecciated, siliceous greywacke with only a few small grains of original feldspar. Quartz is the principal constituent, as tiny interlocking grains and also in secondary veinlets and areas formed by replacement or recrystallization. Pale greenish brown biotite occurs as tiny flakes throughout, and also abundantly in numerous microscopic veinlets with carbonate. Tiny crystals of pyrite are liberally sprinkled through the rock. The south contact of the north tongue of porphyry dips south at 70 degrees or more and is regular except at the west end where it is tortuous and swings southward. This part of the porphyry mass appears to plunge west. The north boundary of the south tongue of porphyry is regular and practically vertical where exposed in two crosscuts. The south boundary of this mass is very irregular and in part follows a sheared zone that dips 35 to 70 degrees south; along this zone both porphyry and greywacke are intensely silicified, but not commercially auriferous. The shearing is apparently the northern fringe of the main fault zone, which passes through the mine and persists eastward along and south of the main drift on this level.

Drill holes put down from the surface in 1935 indicated ore about 400 feet above, and 300 feet east of, the east body on the 500-foot level. Drilling done from the 500-foot level, and the plunge of the porphyry noted above, suggest that the ore dips southward and pitches westward

towards the shaft. This in turn suggests that this body of ore intersected in drill holes from the surface is continuous with the body developed underground on the 500-foot level; in other words, the evidence indicates the presence of a large, pod-shaped body dipping southward about parallel with the main fault zone and plunging west at an angle greater than 45 degrees.

During 1937 the company explored, by drilling from the surface, an area some 650 feet long, which extends westward from the East Malartic boundary just south of the highway. Holes were placed about 100 feet apart. The initial drilling was done jointly with East Malartic Mines on the boundary between the two properties; commercial assays were obtained across great widths. The writers are indebted to the company for the information that subsequent work on Sladen ground has proved an auriferous zone, from about 15 to 35 feet wide, apparently continuous for at least 450 feet west from the property boundary. Additional deposits were encountered north and south in several holes, and some good ore, difficult as yet to correlate with the main zone, was obtained in two holes drilled farther west. The zone lies along the contact between sheared greenstone of the Cadillac belt (Blake River group) and Kewagama group greywacke. Both these rocks are intruded by porphyry, similar to that at the mine, and there is a major, sill-like body of this rock in the greenstone not far north of the contact. The volcanic rocks are highly schistose, and sections of "diorite" similar to that at East Malartic No. 2 shaft were encountered in most holes. For about 400 feet on the east the main ore zone straddles the greywacke-schist contact. At this point the drilling indicates either a sharp, S-shaped drag-fold in the strata or some other structural complexity, and the ore continues west in greenstone schist and porphyry. In greywacke the ore is more or less typical of that found at Canadian and Sladen Malartic mines, i.e., a highly siliceous, dense, cherty rock with disseminated pyrite. Gold also occurs, however, to the north, in pyritic "diorite" and in chlorite-carbonate schist derived from greenstone. Some spectacular pieces of native gold were found in otherwise uninteresting-looking schist of this kind. In other places the ore is silicified, pyritic porphyry. The trend of the mineralized contact throughout most of the distance is east-west, but at the west end it swings to north 60 degrees west, in line with the regional strike of the south contact of the Blake River group. The indicated dip of the contact and ore is 80 to 85 degrees south. No direct connection between the new ore zone and that developed in the mine has been established, though projection of the strike of the latter leads to the assumption that the two would meet near the west end of the newly drilled section.

No underground work has as yet been done on the new ore at the east boundary, but it constitutes a most important part of the potential value of the property. Its west end lies 2,400 feet from the mine shaft and was 1,750 feet from the east end of the 500-foot level in October 1937. Andrew Walz, early in 1938, estimated from the drilling that a body 18,000 square feet in area, or about 1,500 tons a foot of depth, is indicated. Average gold content has not been estimated officially, but it may be reasonably expected to at least equal the average prevailing in the camp.

In 1937 a drill hole located the south contact of the Cadillac belt 1,200 feet north and 700 feet east of the shaft. Porphyry intrusions of small size in greywacke and in sheared greenstone were cut and low gold assays were obtained.

In February 1938 Mr. Walz reported the ore reserves of the property as 750,000 tons of $7 ore. This includes only the east and west ore-bodies of the mine. The former is reported to have been traced by drilling to the 1,000-foot level. During February the mill operated at about 260 tons a day; the grade of mill feed was stated to be $8 a ton.

SLADEN MALARTIC MINES, LIMITED

(Cadillac Township)

Sladen Malartic Mines, Limited, owns sixteen claims east of Lapa Cadillac ground, twelve claims north, and four south, of the township centre line. The company has mapped the property in detail and done a limited amount of trenching.

The property is underlain by strata of the Cadillac group. They consist of greywacke, conglomerate, iron formation, and some beds of tuff and breccia. The latter, and some of the beds of argillaceous greywacke, are locally amphibolitized and chloritized. On the four claims south of the centre line limited outcrops indicate that the beds strike quite uniformly about north 70 degrees west, except for minor drag-folds in some strata. North of the centre line, however, there are sufficient outcrops to show that the rocks are intensely contorted, with complex, steeply plunging, Z-shaped drag-folds predominating. The result is that the strata swing sharply north and northeast in the central part of the claims in a series of complex contortions, a structure that is probably complicated further by faults, though very little direct evidence of them can be obtained on the surface. This area of complex structure is part of a zone of contortion that trends north of east from Maritime Cadillac past the south end of Revillart Lake. The possibility should be borne in mind that there may be major faults trending north of east in this zone, by which the strata to the north are displaced eastward relative to those on the south. Sheared, porcelaneous quartz albitite is exposed in a trench in low ground at the western boundary of the property, 675 feet north of the power line. The northern contact was not exposed in 1936, but it is reported that trenching done in 1937 showed that the body is at least 200 feet wide. It cuts chlorite schist, presumably altered tuff or breccia, and, except for a few dykes of amphibolite, is the only intrusive known on the property. The rock strikes north of east and is similar to quartz albitite and albite porphyry at Deane-Cadillac, Hayes Cadillac, and Rubec.

No deposits of commercial value have been found on the property, but much of the ground is heavily drift covered and only a limited amount of trenching has been done. Quartz veins have been found at widely separated points. In the southeastern corner of the property, south of the

township centre line, small veins and lenses of quartz with minor amounts of ankerite, tourmaline, and pyrite occur in greywacke along a zone striking north 75 degrees east that has been followed by pits for 350 feet. Native gold has been found in small amount at the eastern end, where the greywacke is much fractured and the quartz veins exceedingly irregular.

As the overburden is too deep for trenching in many places, much of the property could be tested only by diamond drilling.

THOMPSON MALARTIC MINES, LIMITED

(Dunlop Consolidated)

This property is in range VI, Malartic township. The only exposures and the workings are on the south halves of lots 7 to 10, a short distance north of Heva River. Camps are built on the north shore of the river in lot 9. Development consists of extensive trenching and a prospect shaft 40 feet deep, as well as several shallower pits. Several years ago M. J. O'Brien, Limited, put down two diamond drill holes, and in 1936 Dunlop Consolidated Mines drilled several holes.

The contact between the Blake River group and the Kewagama group to the north strikes north 60 degrees west across the property. Exposures reveal a thickness of some 800 feet of volcanic rocks of the northern part of the Blake River group. The strata are highly altered, extensively sheared, and locally highly contorted. They include andesitic pillow lavas, a few beds of tuff, and one or more bodies of sheared, dioritic material that may be intrusive. North of the volcanic rocks fine-grained, argillaceous to siliceous greywacke of the Kewagama group is moderately well exposed across a width of 900 feet. The contact between the two groups is conformable and gradational, so that over 80 or 90 feet it is very difficult to decide whether the grey to greenish strata should be considered as essentially volcanic or sedimentary. North of that the greywacke is thin bedded. The strata dip 65 to 75 degrees southward.

Beginning about 500 feet north of the contact, a swarm of grey to brownish, fine-grained, feldspar porphyry dykes follows the bedding of the sedimentary rocks in a zone 50 to 60 feet wide. North of this, but separated from it by about 200 feet of greywacke free of dykes, there is a multitude of small and large porphyry dykes throughout a large area of greywacke. Random outcrops of granite in lower ground to the east and northeast, near the northern boundary of the property, suggest that this drift-covered area may be underlain by a large body of granite.

Across a maximum width of about 300 feet south of the contact with greywacke, the volcanic rocks are intensely carbonatized along several bands up to 30 feet wide that follow the strike of the beds in general, but in the shaft area merge to give an irregular, highly carbonatized width of nearly 200 feet. The carbonates are ferruginous and weather red or brown, so that they stand out in marked contrast with the uncarbonatized, green or grey, schistose strata. In addition, the carbonatized material is mineralized, erratically and sparingly, with pyrite, pyrrhotite, and, rarely, chalcopyrite, and is cut in many places by small, irregular veins of white quartz and ankerite. Some of these veins carry coarse, black biotite and

small amounts of tourmaline. The most heavily mineralized area, near and southeast of the shaft, is one in which the volcanic rocks have been strongly sheared and drag-folded; some of the drag-folds plunge 60 degrees or more toward the east. The O'Brien drill holes were put down from the south, at 45 degrees, to cut this heavily carbonatized zone. They encountered large widths of carbonatized and mineralized rock. With one exception, the core did not carry commercial values, and most of it was barren. Twenty inches of mineralized, carbonatized rock near the collar of No. 2 hole returned $7.40 a ton in gold at $20 an ounce.

The shaft was sunk on a coarsely crystalline, white quartz vein in the contact zone. As exposed now in the corner of the shaft it is 9 to 12 inches wide and is sparingly mineralized with pyrite, galena, and chalcopyrite. It carries some ankerite and the south wall is carbonatized. It is reported that some encouraging gold assays have been obtained from this vein, and that low assays were found across a width of 13 feet in a south crosscut at the bottom of the shaft. The vein dips 65 degrees south.

A few narrow veins and vein zones of white quartz, with scattered small amounts of tourmaline and pyrite, have been exposed in greywacke to the north. None of them seems to offer much encouragement to further development.

It may be noted here that a carbonatized zone similar to that at this property has been found at the same horizon at Malrobic and Panamint, the latter over 2 miles to the southeast. Northwest, to and past the pronounced bend that is assumed in the formations, the contact zone along which it occurs is heavily drift covered.

TRUE FISSURE MINES, LIMITED

True Fissure Mines, Limited, holds fifteen surveyed claims immediately northeast of Rubec Mines, in Cadillac township. Originally belonging to Stonetrue Gold Mines, Limited, the property was developed by Bell River Gold Mines in 1934, lay idle in 1935, and was acquired by True Fissure Mines in 1936. Late in the year a camp was erected, and it is reported that some diamond drilling was done during the winter. The writer is indebted to John B. DeMille for records of the work done in 1934.

The northern band of the Blake River group strikes nearly due east through the middle of the property and probably starts to swing southeast in the eastern part, where it is drift covered. The total width of the group is about 2,000 feet. Exposures are scarce, but some 1,300 feet on the north is dominantly andesitic flows. Some horizons are well pillowed, others dense or finely crystalline and dioritic in appearance.

To the south a zone of 300 to 400 feet wide is almost entirely grey to white rhyolite and rhyolite porphyry, partly sheared to quartz-sericite schist. The southern 200 feet or so of the group is a mixture of altered lava, tuff, and agglomerate, with, in at least one place, some interbedded conglomerate. The contact against the Cadillac group to the south is not exposed. Farther south in a few small exposures greywacke is cut by small quartz veins.

North of the Blake River group is about 1,000 feet of greywacke of the Kewagama group, bordered on the north by lavas and ejectamenta of the Malartic volcanics. Agglomerate and some conglomerate occur along the contact zone.

A great many small dykes of albite porphyry and biotite-albite porphyry lie parallel to the bedding of the Kewagama group, and are particularly abundant in the northern half. A large dyke of quartz gabbro (younger diabase) trends north of east across the northwestern part of the property, and a branch from it strikes west of south across the Blake River volcanics.

All the rocks except the porphyry dykes and the quartz gabbro are in part schistose. The schistosity, with rare exceptions strikes parallel to the bedding; its average dip is 70 to 80 degrees south. Determinations on pillow lavas indicate that the tops of the beds face south. A number of minor, northeasterly trending faults with left-hand offsets were observed.

A great many quartz veins inject the Blake River volcanic and the Kewagama sedimentary rocks. Those in greenstone are remarkable for the abundance of well-crystallized black tourmaline in the quartz and in the adjoining, altered rock. Moderately coarse-grained pyrite is the principal metallic mineral, but there are minor amounts of arsenopyrite in most of the showings. Where albite is abundant in the veins, sulphides are commonly rare or absent. Ankerite accompanies some of the quartz, and late veinlets and pockets of calcite are not uncommon. Epidote and actinolite form in the altered wall-rock. The quartz is white or vitreous and smoky.

So far as the writers know, up to 1936 no great lateral extent has been proved for any of the veins or vein zones on the property, nor has systematic sampling yielded commercial ore, although grab samples have been reported to carry gold in important amounts. A vein zone in greenstone at the north side of claim A59588 has been trenched and diamond drilled; an irregular vein of quartz, tourmaline, and pyrite is exposed for over 100 feet and is up to 5 feet wide, but averages not much over 1 foot. At the west end two lenses, 15 and 30 feet long, respectively, are each offset 5 to 10 feet to the north. Two drill holes put down by Bell River Gold Mines are reported to have cut similar vein material at depth. Two feet of the same type of vein material is exposed in a pit 200 feet west, and there are other similar veins, up to 5 feet wide but much shorter, in several old pits to the south.

A number of very irregular veins and vein zones of quartz and tourmaline have been found in rhyolite, particularly in massive, dyke-like bodies in more highly sheared lava. A trench at the north edge of the rhyolite horizon, 1,750 feet west of the camp buildings, shows a foot or two of narrow quartz stringers with arsenopyrite crystals, up to one-half inch across, abundantly disseminated in the wall-rock. Other small veins of quartz, tourmaline, and arsenopyrite occur in this part of the property. Three drill holes were put down by Bell River Mines to test some of these showings and to explore the drift-covered strata south of the rhyolite.

Some quartz veins and a narrow, pyritic, quartz-veined shear zone have been found in andesitic lavas adjoining the later diabase dyke in the western part of the property.

The writers have no information concerning the results of exploration by True Fissure Mines in 1936.

VALCO CADILLAC MINES, LIMITED

Valco Cadillac Mines owns two properties in range V, Malartic township. The eastern property is on the south shore of Malartic Lake and includes lot 41 and the south halves of lots 42 and 43. No work has been done there for several years. The old camp is at the southeast corner of a bay on Malartic Lake.

The eastern claims are underlain by volcanic rocks of the Malartic group and by intrusives. There are a few outcrops of andesitic lava and breccia along the shore of Malartic Lake and some exposures of granodiorite on the northwest side of the bay. Not far north of the old camp on the lake shore, lava and agglomerate are cut by small dykes of feldspar porphyry and dense, porcelaneous aplite. Volcanic strata and dykes strike north 60 degrees west, with nearly vertical dips. In one place an old trench shows 9 feet of completely carbonatized andesite, and breccia to the north is carbonatized in irregular patches.

In the southern 1,400 feet of the property several prominent rock ridges, separated by drift-covered depressions, trend north 70 degrees west. The ridges consist largely of andesitic, basaltic, and dacitic lava, with intercalated tuff and agglomerate. In the southwest corner there are narrow sills of serpentine. Dykes of granite and grey to brown, feldspar porphyry are very abundant across 400 feet at the northeast side of the volcanic outcrops. They lie parallel to the strike of the older rocks and range from a few inches to 70 feet wide. There are also a few small lamprophyre dykes.

Northeast of the volcanic ridges, and separated from them by a depression 200 to 400 feet wide are good exposures of brown to grey, albite granite over an area 1,300 feet from east to west and about 300 feet wide. The rock consists essentially of quartz, albite, and microline, and is similar to many of the dykes to the south. Further petrologic details have been given under "General Geology".

The granite is sheared and sericitized in places, and quartz veins have formed in the shear zones. It is also extensively veined and replaced by white quartz with which are associated small amounts of chlorite and muscovite. Quartz is particularly abundant for 100 feet or so north of the south contact in the western half of the exposures, where areas of several hundred square feet are 60 to 90 per cent quartz. Elsewhere there are many fissure veins in the granite.

The south contact of the granite is exposed in three pits. The contact strikes nearly due east, is probably sharply bent or faulted, and is practically vertical. In the western pit a width of 40 feet of chlorite schist south of the contact is intensely carbonatized and carries small amounts of pyrite and pyrrhotite. A green hue is imparted by streaks and lenses of bright

green, chrome-bearing mica and chlorite. Four hundred feet east, 10 feet of the same material is exposed at the south contact of the main granite mass, but is bordered on the south by at least 10 feet of crushed, seriticized granite. The third pit, 350 feet farther east, shows 10 feet of rusty, carbonatized schist between schistose granite walls. This pit and the trenches north of it are probably just on Bayside Malartic ground, east of the Valco boundary.

Many of the dykes to the south are cut by white quartz veins. The largest dyke is partly exposed in several places 600 feet south of the pit first described. It ranges from 10 to 70 feet wide and may extend across the property, but there are insufficient outcrops to prove definitely its continuity. In an old pit near the east end of the exposures it is heavily mineralized with quartz and minor amounts of tourmaline, pyrite, and pyrrhotite. Some trenches 1,700 feet west expose similar material across widths up to 14 feet, and the adjoining greenstone is carbonatized and pyritized.

J. J. Guntensperger, the company's geologist, informed the writers in 1935 that samples from the eastern group of claims had not returned any important gold assays.

The western claims include the south halves of lots 1 to 5, range V. Developments there to late 1936 consisted of trenches and a few test pits. In 1937 and 1938 a campaign of diamond drilling was completed.

The claims are underlain by the Cadillac group, including greywacke, conglomerate, magnetite beds, and green, probably tuffaceous, chlorite and amphibole-bearing beds. The strata strike 15 degrees south of east, and have a consistently steep dip, ranging from 75 degrees south to vertical.

Exposures within the claims fall into two groups, a northern group extending almost across the full width of the claims, and a southern group centred on a ridge near the Cadillac-Malartic township line. Crossbedding is perfectly developed in the northern exposures and shows beyond doubt that these beds face south. In the southern group, crossbedding and grain size gradation show almost equally well that the beds face north. There is, therefore, a synclinal axis that trends north 75 degrees west in the low ground between the two groups of exposures. This is in fact the axis of the major syncline of the area.

A few small cross-faults are exposed on the southern ridge. These fall into two sets, one striking north 40 degrees east, on which the horizontal offset is left hand, and the other striking north 20 degrees west, on which the offset is right hand. The dip of all these faults is nearly vertical, and the horizontal offset is generally not over 3 feet.

Quartz and tourmaline occur abundantly in a zone that is exposed intermittently for 2,400 feet along the southern side of the northern group of outcrops. The zone trends nearly due east, and thus crosses the bedding at a small angle. The mineral deposits consist of a number of scattered, irregularly shaped veins of quartz and black tourmaline, the majority less than 50 feet long and only a few inches wide; in many places the adjoining greywacke is partly or completely replaced by tourmaline. The largest vein measured is 30 inches wide and has 2 feet of tourmalinized greywacke on either wall. Sulphides are present in small amount and the wall-rock is partly carbonatized.

There are other quartz veins in greywacke and conglomerate on the claims, especially in the southern group of exposures. Some of these have been trenched without giving much encouragement. A good many are arranged *en échelon* in beds that strike uniformly 15 degrees south of east. Such veins strike almost due east, and are restricted to a single bed, their lengths being determined, therefore, by the thickness of the bed.

A quartz vein that is reported to carry visible gold is exposed in a deep trench in low ground near the south side of the northern exposures in lot 2, range V. This No. 1 vein is exposed for 60 feet along its length; it is 2 inches wide at the west end, 10 inches at the east. The greywacke in which it lies is sheared and carbonatized over widths up to 4 feet. The quartz is white to vitreous; associated minerals are biotite, chlorite, and, along fractures through the quartz, a little white mica. Sulphides include arsenopyrite and pyrite, both in quartz and in the wall-rocks.

Through the kindness of Mr. Guntensperger the writers obtained data on the 1937 and 1938 drilling and inspected some of the core. It is reported that No. 1 vein zone was traced by closely spaced drill holes for a length of 700 feet, and that free gold was found in four holes. The average width of the mineralized zone is given as 2½ feet. Hole 10 shows 10 inches of grey quartz, sparingly mineralized with aresnopyrite and pyrite, in sericitized and slightly mineralized greywacke, immediately south of a 10-foot bed of conglomerate. Fifteen specks of native gold were counted in the quartz, which also carries small proportions of chlorite and tourmaline. Hole 17 was collared 150 feet south of No. 1 vein and drilled southward across the depression that marks the location of the major synclinal axis. The core is largely of greywacke, with some narrow beds of conglomerate towards the collar, and shows 120 feet of moderately to strongly sheared greywacke under the middle of the depression, with the most pronounced schistosity at the south side. Within the 120 feet several zones of grey quartz were cut, accompanied by moderate amounts of arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. Five and one-half feet of such material was encountered in one place, but no assays of more than a few cents a ton are reported.

ZULU GOLD MINES

(Pand Ore Mines)

This company is reported to control a group of claims west of Lapa Cadillac. In 1936 several holes were drilled under the supervision of Lapa Cadillac officials. They intersected a series of interbedded volcanic and sedimentary rocks along and south of the highway west of the Lapa Cadillac boundary. These rocks are in large part converted to mica and chlorite schist and are intruded by bodies of quartz albitite and albitite. The results seem to prove the continuity of the Cadillac belt from Pandora to Lapa Cadillac, and as well the persistence of intensely sheared zones within the belt. It is reported that a low gold content was found in several holes across substantial widths. The writers made only a cursory examination of the drill cores.

PLATE I

82273

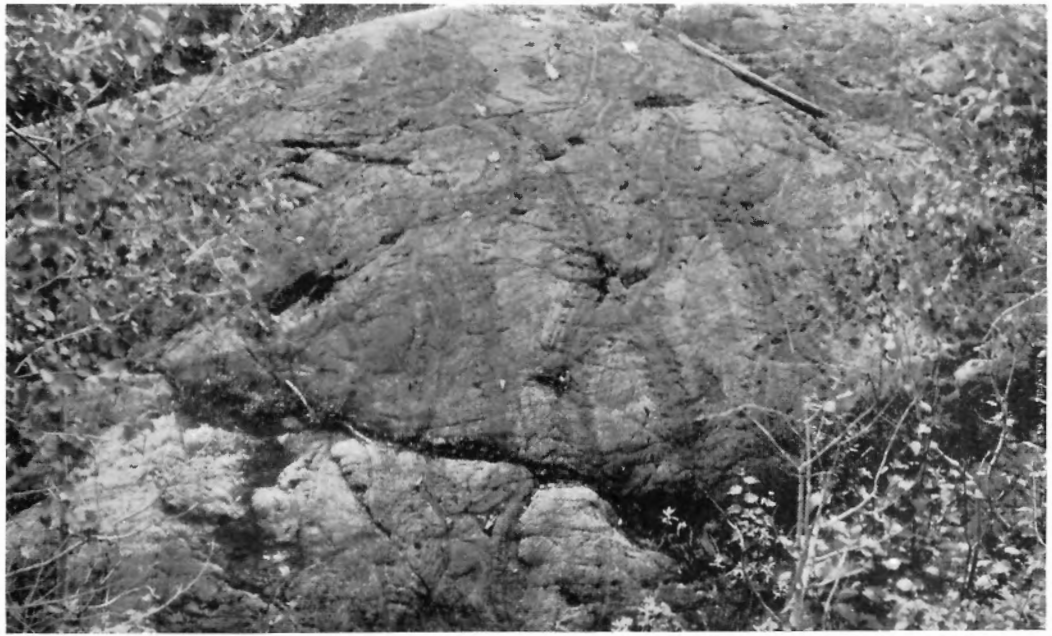
Photograph of drill cores. (Page 18.)

91708—10

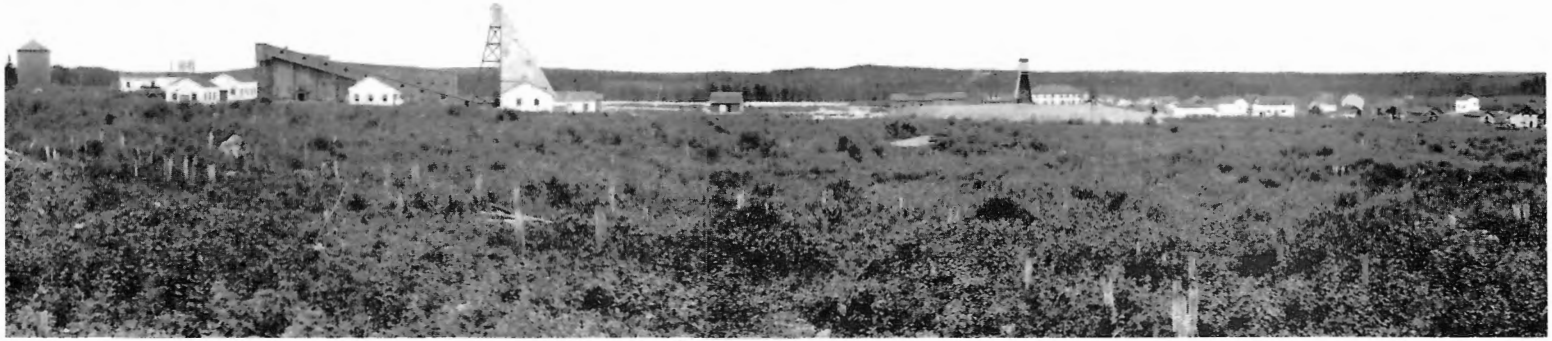
81945 A. Brecciated granodiorite. (Page 28.)

B. Veins of quartz in albite porphyry dyke. (Page 30.)

PLATE III



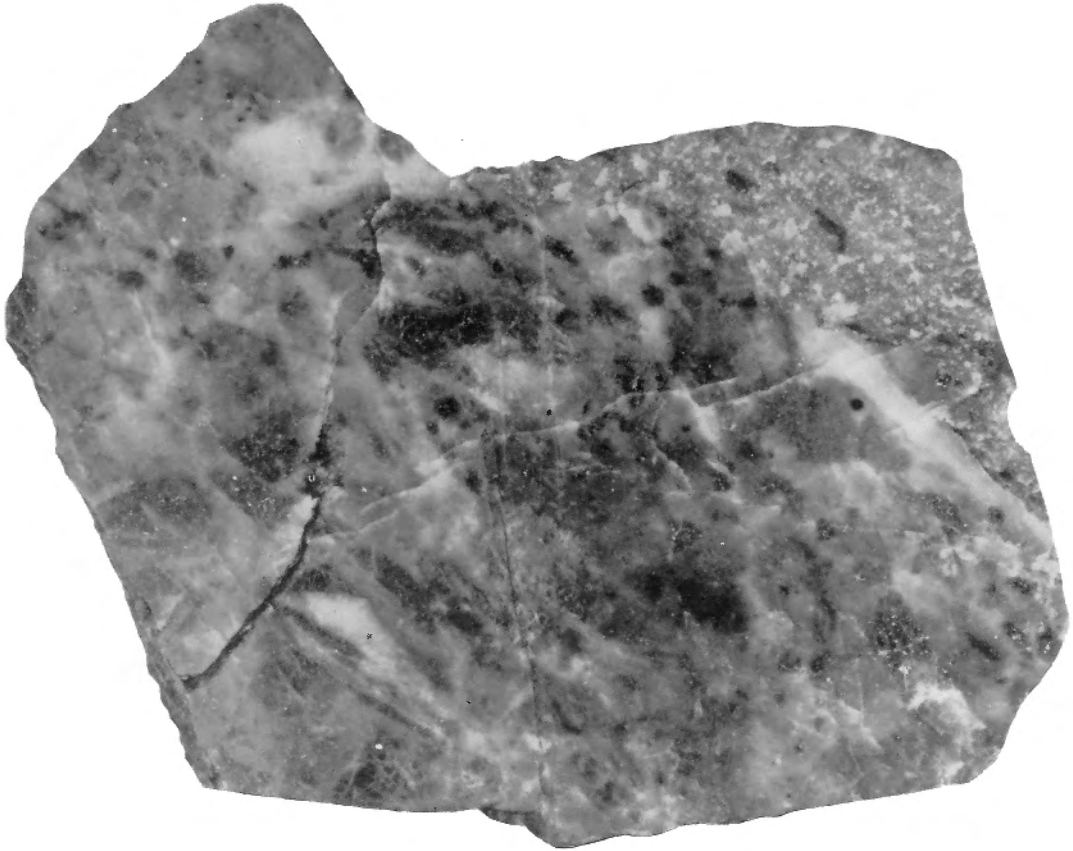
Pillowed andesite, Malartic township. (Page 41.)



81949 81950

Panorama looking north at Canadian Malartic mine, September 1936, No. 1 shaft, right; No. 2 shaft, left. (Page 68.)

77382
Mineralized schist and lenticular albitite intrusives, Pan-Canadian Gold Mines, Limited. (Page 105.)



82276

Silicified, brecciated greywacke. Ore from first level, Sladen Malartic mine. Minute white specks are sulphides and tellurides. (Page 119.)

82270

High-grade gold-quartz ore, first level west, Sladen Malartic mine. Black bands are disseminated, fine-grained sulphides, tellurides, and gold in quartz. Natural size. (Page 120.)

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