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GEOLOGY OF WATTERSON LAKE (west half) MAP-AREA, DISTRICT OF KEEWATIN

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K.E. EADE
F.W. CHANDLER

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DISTRICT OF KEEWATIN

K. E. EADE and F. W. CHANDLER

Abstract

Watterson Lake (west half) map-area is in the Churchill Structural Province, west of Hudson Bay. Old metamorphosed volcanic and sedimentary rocks, the Henik Group, gneissic rocks, and intrusive rocks ranging in composition from quartz monzonite to anorthosite and gabbro, are all probably Archean. They are overlain by the Hurwitz Group and by the Bate Lake sediments, the relations of which are uncertain. Deformed orthoquartzite of uncertain age, in a single small isolated occurrence, cannot be related to the other sedimentary rocks. An Aphebian quartz monzonite pluton intrudes the Bate Lake sediments and Archean gneisses. A small part of a large pluton of Nueltin Lake granite of Helikian age occurs in the southeast corner of the map-area.

Sulphide-bearing zones are common in the metamorphosed volcanic rocks, but assays from a number of occurrences failed to indicate economic values.

Résumé

La région du lac Watterson (moitié ouest de la carte) s'étend dans la province structurale de Churchill, à l'ouest de la baie d'Hudson. On y trouve d'anciennes roches volcaniques et sédimentaires métamorphisées, le groupe d'Henik, des roches gneissiques et des roches intrusives, dont la composition va de la monzonite quartzifère à l'anorthosite et au gabbro; toutes ces roches datent probablement de l'Archéen. Elles sont recouvertes par le groupe d'Hurwitz et les sédiments de Bate Lake dont les relations sont incertaines. Un orthoquartzite déformé, d'âge indéterminé, d'une seule petite venue isolée, n'a pu être rattaché aux autres roches sédimentaires. Un batholite intrusif de monzonite quartzifère, de l'Aphébien, a pénétré les sédiments de Bate Lake et les gneiss de l'Archéen. Une petite partie d'un grand batholite de granite de Nueltin Lake de l'Hélikien, se trouve dans la région de l'angle sud-est de la carte.

Les roches volcaniques métamorphisées renferment couramment des zones à teneur en sulfures, mais les analyses d'échantillons d'un certain nombre de venues n'ont pas permis d'en préciser la valeur économique.

Introduction

Watterson Lake (west half) map-area is in the southern part of District of Keewatin, its centre being 265 miles northwest of Churchill, Manitoba, 182 miles west of Eskimo Point, on the Hudson Bay coast, and 325 miles north-northeast of Lynn Lake, Manitoba. Both Lynn Lake and Churchill have air and rail facilities, and air services, available from charter aircraft companies, provide access to the area. A private airstrip at the southwest corner of Cullaton Lake is only 17 miles east of the east boundary of the map-area. There are no permanent residents in the region.

Travel in summer is by float-equipped aircraft, helicopter or on foot. Small boats and canoes can be used on the lakes but the rivers are not easily navigable.

Relief is gentle throughout the area, commonly less than 100 feet. Pleistocene deposits are extensive and rock exposures are scarce.

The Geological Survey mapped the area in 1952 as a part of the geological reconnaissance of southern District of Keewatin (Lord, 1953; Wright, 1967). Lee (1959) described observations on the Pleistocene geology made during the regional study. Aeromagnetic maps covering this region have been published by the Geological Survey at scales of one inch to one mile and one inch to four miles. An exploration lease covering the southeast quarter of the map-area was held by Eldorado Mining and Exploration and in 1969 the company carried out extensive geological exploration. The present study was done between June 16 and July 18, 1973. A Bell 47-G4A helicopter was used for regular air traverses spaced at intervals of three miles to outline the main bedrock geology, for check traverses in areas of complicated geology of rare outcrop, and to position crews for ground traverses to fill in more details of the bedrock geology. The writers were ably assisted in the field by D. S. Faust, D. R. Troyer, W. R. Skinner, and J. C. White. The helicopter pilot-engineer, E. Krowski, provided competent service under difficult conditions.

General Geology

The area is a part of the Churchill Province of the Canadian Shield. The oldest rocks are believed to be metamorphosed volcanic and sedimentary rocks of the

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Henik Group and gneissic rocks derived, at least in part, from the sedimentary rocks. Old plutonic rocks range in composition from granodiorite and quartz monzonite to gabbro and anorthosite. All the above supracrustal, metamorphic and plutonic rocks are considered to be Archean.

Aphebian sedimentary rocks, the Hurwitz Group and the Bate Lake sediments, unconformably overlie the Archean rocks. Orthoquartzite, in the small isolated area that is separated from all the other sedimentary rocks, may be either late Archean or early Aphebian. A late Aphebian quartz monzonite pluton intrudes Bate Lake sediments but in this map-area it does not affect Hurtwitz Group rocks.

Early Helikian Nueltin Lake granite is present only in the southeast corner of the map-area, being part of a larger pluton extending to the south and east. Helikian Mackenzie diabase dykes are poorly exposed and only small segments of dykes have been seen.

Henik Group

The term 'Henik Group' for the sequence of metamorphosed Archean volcanic and sedimentary rocks in the adjoining Kognak River map-area was introduced by Eade (1974) and is used in this area as occurrences of these rocks are continuous between the map-areas.

The metavolcanic rocks (Av, Au, Af, Am) occur in two main bands. The first is a narrow short band northeast of Watterson Lake; the second, to the north, a wider and longer arcuate band extends northwest from southeast of Sutcliffe Lake to beyond the boundary of the map-area north of Gregoire Lake. In the first band, outcrops are abundant and subdivision of the rocks into felsic, basic, and ultrabasic units is possible. Basic volcanic rocks (Am) are most abundant and consist of dark green, fine-grained rocks of basalt to andesite composition. Pillow structures are preserved in a few places but for the most part the rocks are massive, although secondary cleavage is ubiquitous. Metamorphism has affected the rocks and in thin sections it is apparent that they are completely recrystallized. Common green hornblende and plagioclase are the major constituents, with actinolite present in some places. A few thin bands of finely laminated iron-formation, consisting of quartz, magnetite and grunerite, occur with the basic volcanic rocks.

Ultrabasic rocks (Au) on the north side of the volcanic band are fine to medium grained, dark green to black and commonly have a rusty brown weathered surface. In some places, distinctive "spinifex" texture is typical of these rocks. They consist almost entirely of serpentine, in part tremolitized, with only remnants of original pyroxene preserved. Magnetite is an abundant accessory mineral, and accounts for the marked response shown by this unit on the aeromagnetic maps. Although massive for the most part, possible flows, 5 to 6 feet thick, with some possible flow breccia, are present here and there.

A small area of metamorphosed felsic volcanic rock (Af'), preserved on the south side of the volcanic band, consists of quartz-feldspar schists containing scattered elongate clasts of fine-grained felsite. The schists are thought to be derived from felsic agglomerates and tuffs.

Amphibolite (Amm) north of Watterson Lake is separated from the volcanic band but is probably derived from similar basic volcanic rocks (Am). The dark green medium- to fine-grained amphibolite typically has a good foliation and in part is banded, with hornblende- and plagioclase-rich layers. Common green hornblende and andesine are the major constituents. A few small scattered occurrences of amphibolite (Amm) in the western part of the map-area are similar to the one north of Watterson Lake.

In the northern volcanic band, small areas of basic (Am) and felsic to intermediate (Af) rocks are shown on the map but most are undifferentiated (Av) due to lack of data, the result of sparse outcrop in parts of the band. All the rocks are moderately metamorphosed. In the basic rocks hornblende and plagioclase are completely recrystallized and some foliation is commonly evident. No primary structures have been seen in any of these rocks. The felsic volcanic rocks (Af) range in composition from rhyolite to quartz latite or latite and in part retain a clastic texture indicating an origin as tuffs or water-lain volcanogenic rocks. However, in thin sections there is a lack of evidence of shard-shaped grains or devitrified glass usually associated with tuffs. These clastic rocks consist of subangular to subrounded grains of plagioclase, with some quartz, potassic feldspar, and quartz-feldspar fragments, in a very fine matrix – principally sericite, with minor chlorite and/or biotite. Felsic flow rocks are less abundant than tuffs or volcanogenic sediments of similar composition.

Sedimentary rocks of the Henik Group (As) are confined to a single band in the north-central part of the map-area. Ranging in composition from medium-grained greywacke to fine-grained siltstone, the rocks typically have good bedding, from ½ inch to 6 inches thick. Varying proportions of quartz, feldspar and rock fragment grains in a matrix of sericite, biotite and/or chlorite make up most of these rocks although in some places hornblende or grunerite is a major constituent. Pyrite is a common accessory in almost all rocks. Finely laminated quartz-magnetite iron-formation occurs with the greywacke and siltstone in a few localities. In composition, the sedimentary rocks are very similar to some tuffs of the volcanic unit (Af), and it is likely the sedimentary rocks are largely volcanogenic. In the greywacke and siltstone unit bedding is much better developed and grains are more rounded than in compositionally similar tuffs.

Biotite usually forms metacrysts in the sedimentary rocks and is the result of regional metamorphism. On the east, sedimentary rocks pass gradationally into paragneiss (Asn) as a result of increasing metamorphism. On the west, anorthosite intrudes greywacke and siltstone although, for the most part, the contact is a fault or is obscured by glacial drift. In one locality where the intrusive contact is exposed, the greywacke and siltstone are converted to a dense, black hornfels.

Paragneiss or pelitic gneiss (Asn) which is commonly migmatized, is confined to the northern half of the map-area. These rocks are considered to be derived from sedimentary rocks equivalent to the metagreywacke and siltstone (As). The paragneiss is composed of a grey paleosome of quartz, plagioclase and biotite, in varying proportions. Garnet is commonly present in the grey bands and sillimanite is present here and there. Well developed foliation and a marked granoblastic texture are typical of these rocks. White coarse-grained to pegmatitic bands, veins or segregation of quartz-plagioclase leucosome are present in the grey paleosome in many places but not everywhere. The form of the leucocratic component varies from regular interbanding in the more mafic paleosome, to augenitic with augen-like enlargements of the leuco-bands or less commonly, to a veined type consisting of crosscutting dykelets.

Amphibolite bands occur within the paragneiss although not abundantly except just west of the anorthosite pluton. A sample of amphibolite from that locality comprises hornblende, epidote, carbonate and altered plagioclase. The origin of the amphibolite bands which may have been derived from carbonate-rich sedimentary rocks or from basic sills and flows, is not known.

Rocks of the paragneiss unit are in the almandine-amphibolite facies of metamorphism, for the most part in the lowest staurolite-almandine subfacies but here and there the higher sillimanite-almandine-muscovite subfacies (Turner and Verhoogen, 1960) is represented.

Gneissic Rocks

Layered gneiss (Anl) occurs throughout the western half of the map-area being most abundant in the southwest corner. Prominent light and dark layers commonly from 1 to 6 inches thick are characteristic of these rocks. They are medium grained and typically have a granitoid texture. Quartz, plagioclase, and biotite are major constituents whereas microcline may be either a major or minor constituent. Hornblende commonly accompanies biotite in the southwest quarter but in the northwest quarter, epidote occurs with the biotite. Rocks of this unit have gradational contacts with the granodiorite gneiss (Ang) but are intruded by the quartz monzonite to granodiorite (Agd).

Granodiorite gneiss (Ang) is the most widely distributed rock type in the map-area. Typically the grey, medium-grained, granitoid gneiss is well foliated but variations exist; on the one hand, foliation may be weak and the rock almost massive or, at the other extreme, incipient layering may be present. Biotite-rich schlieren or inclusions are scattered throughout and here and there strong shearing has produced cataclastic texture in the gneiss. Compositionally the rocks are granodiorites, with quartz, plagioclase, and biotite being major constituents and microcline a minor constituent. However, adjacent to contacts with plutons (Agd, Agdm) microcline content increases. Hornblende accompanies the biotite in the granodiorite gneiss only around the north part of Hicks Lake. Epidote is a minor constituent of the gneiss everywhere except east and southeast of Boland Lake where it is rare or absent.

Dark grey to greenish grey gneiss of quartz dioritic composition is mixed with the granodiorite gneiss west and north of Watterson Lake. A small area north of Watterson Lake composed almost entirely of quartz diorite gneiss (Ang') is shown on the map. The andesine in the quartz diorite gneiss is commonly more altered than is the oligoclase of the granodiorite gneiss and epidote is more abundant in the quartz diorite gneiss.

Plutonic Rocks

Archean felsic plutonic rocks range in composition from quartz monzonite to granodiorite or more rarely, to quartz diorite. With the exception of the small quartz diorite (Agd') pluton west of Watterson Lake, plutons in the southern part of the map-area range from quartz monzonite to granodiorite (Agd), with varying proportions of microcline and plagioclase in the rocks. On the other hand, in the central and northern part, the plutons are more consistently quartz monzonite (Agdm), with the exception of the small portion northeast of Boland Lake that is almost entirely granodiorite. Some of the quartz monzonite identified as Archean may possibly be the similar, younger quartz monzonite (Agm). These medium-grained, massive, granitoid rocks are pink, or less commonly grey, and inclusions of schlieren are uncommon. Low mafic content (typically a maximum of 6 per cent biotite) is characteristic except in the quartz diorite which contains approximately 12 per cent biotite. Minor (1 to 2 per cent) muscovite accompanies the biotite here and there. Contacts of the plutons with the intruded older gneissic rocks are well defined although some mixing of the rocks is seen. An exception is the body east of Watterson Lake where massive quartz monzonite to granodiorite is completely gradational into granodiorite gneiss.

Gabbro to metagabbro (Ab) comprises an elongate north-trending stock intruding paragneiss north of Boland Lake and a much smaller body cutting the paragneiss northeast of Gregoire Lake. The dark green, medium-grained rock consists of hornblende almost completely altered to chlorite, and plagioclase, much altered to sericite and clinozoisite, along with accessory magnetite. The texture varies from granitoid to granoblastic and relict ophitic texture is found in places. Foliation is present here and there, particularly near the contacts of the plutons, and cleavage is common. Near the southern contact of the larger mass, pink granophyre cuts the gabbro, perhaps representing a late segregation from the gabbro magma or possibly related to younger granitoid intrusions. Relations of the gabbro to the small granodiorite (Agd) stock, just to the southeast, are unknown as the contact is drift-covered. An east-trending quartz-feldspar pegmatite dyke cuts the gabbro near the north end of the large body.

An elongate pluton of anorthosite (Aa) occurs just to the northeast of the large gabbro body and has a similar trend. The greater part of the mass is anorthosite and although the outer part contains more mafic minerals and is anorthositic gabbro, the pluton is noteworthy for the minor amount of gabbro or gabbroic phases accompanying the anorthosite. Labradorite, the main constituent, is partially altered to zoisite, hornblende grains are rimmed by epidote and stringers of actinolite-tremolite cut both plagioclase and hornblende. Sphene is the only common accessory mineral. The marginal anorthositic gabbro phase is foliated and some recrystallization of minerals has taken place but elsewhere the rock is massive and the original texture is preserved. The anorthosite intrudes both Henik Group paragneiss and metagreywacke.

The relationship of the anorthosite to the nearby gabbro pluton is unknown. Although it is possible they belong to the same mafic suite, the anorthosite seems to be less metamorphosed. The location of the anorthosite intrusion is perhaps related to the north-trending fault. If this is a very old fault, the intrusion could have been localized along it and later movement on the fault dislocated the pluton. The intrusion is possibly a late event of the Kenoran orogeny and the alteration and recrystallization may be related to the Hudsonian orogeny.

The old gabbro dykes (Adb) for the most part trend northeast or north to slightly west of north and typically the rocks are metamorphosed and recrystallized. Only rarely is relict diabasic texture retained in these rocks. Hornblende and plagioclase are the major constituents, with minor biotite and quartz commonly present; magnetite is a very minor accessory (1 per cent or less). Foliation and cleavage occur in some of the dyke rocks but others are massive. These dykes, due to their low magnetite content, do not show on the aeromagnetic maps. The trend of the dykes, their recrystallization, and foliation where present, distinguishes them in the field from the younger gabbro dykes (Hdb).

Quartzite

The age of quartzite (A'q) that occurs in a single locality southwest of Boland Lake, cannot be determined with data presently available and no correlation with other quartzite units can be suggested. It is a very pure orthoquartzite, composed of more than 90 per cent quartz, with minor muscovite and biotite, and accessory magnetite, apatite and zircon. The original texture of the rock has been destroyed and the present texture consists either of interlocking intergrowths of quartz grains or a cataclastic texture resulting from the abundant fracturing. No sedimentary structures were seen although here and there vague compositional layering is apparent. The presence of well rounded zircon grains suggests a sedimentary origin (i.e., an orthoquartzite) and that the rock is not a sheared and fractured giant quartz vein.

Contacts of the quartzite with the adjacent layered gneiss (Anl) and quartz monzonite (Agdm) are not exposed. A few small veinlets of pink quartz-feldspar granite cut the quartzite, suggesting that the quartz monzonite is younger than the quartzite. However, as stated previously, there is doubt as to the age of some of the quartz monzonite and some may be younger (Agm). The character of the orthoquartzite, which is a massive, vitreous, annealed quartz rock, lacking sedimentary structures, in contrast to the orthoquartzite of the Hurwitz Group Kinga Formation, suggests it has undergone an additional metamorphic event as compared to the Hurwitz Group and, hence, is Archean.

Hurwitz Group

Rocks of the Hurwitz Group occur only in the vicinity of Watterson Lake and a small area in the southwest corner of the map-area. At Watterson Lake and adjoining Elliot and Vera lakes, the outcrop pattern of the folded Hurwitz Group accounts for the remarkable shape of the lakes. The orthoquartzite Kinga Formation, which commonly forms ridges, is the only unit of the Hurwitz Group with better than extremely poor outcrop.

Padlei Formation The name, 'Padlei Formation' was introduced by Bell (1970a) for the basal polymictic conglomerate (AHP) of the Hurwitz Group. The formation is restricted in this map-area to two small occurrences in Watterson Lake basin, one north of the lake, the other east of the lake, and a single outcrop in a small lake on the east side of Hurwitz Group rocks in the southwest corner of the area. North of Watterson Lake, subrounded pebbles, up to 3 inches in diameter and with an average diameter of one inch, occur in a matrix of greenish greywacke. The clasts are approximately 70 per cent white quartz and the remainder chiefly of medium-grained, reddish, felsic quartz monzonite. A covered interval of 25 feet separates the conglomerate from the underlying quartz diorite gneiss (Ang'). The overlying, apparently conformable orthoquartzite of the Kinga Formation (AHK), is also separated from the conglomerate by a narrow covered interval. East of Watterson Lake, the conglomerate is similar, although clasts are larger, ranging up to 6 inches in diameter; in addition to the predominant white quartz, and quartz monzonite clasts, scattered clasts of grey granodiorite gneiss and dark green amphibolite are present. The conglomerate there is strongly sheared, with stretched clasts. The direction of shearing parallels that in the underlying granodiorite gneiss, which contains abundant amphibolite bands and inclusions. In the single conglomerate outcrop in the southwest corner of the area, stretched rounded cobbles of pink granodiorite to quartz monzonite are in a metamorphosed feldspathic greywacke matrix.

Kinga Formation In this map-area, orthoquartzite of the Kinga Formation (AHK) is the usual basal unit of the Hurwitz Group. The name, 'Kinga Formation', was introduced by Bell (1970a) and he subdivided the formation into two members, the Maguse and Whiterock Lake. No subdivision is possible in this area and it is probable that only the equivalent of the Whiterock Lake Member is present. The orthoquartzite is dominantly white, but shades of pink, grey, and light purple are also present. It is fine grained, thin to medium bedded, ripple-marked in places, and cut by white quartz veins. Thin sections of the typical orthoquartzite show the rock to consist of 95 to 99 per cent quartz, with the remainder being interstitial sericite or greenish muscovite. The quartz grains are well rounded, with good sphericity, well sorted, and with some overgrowths; diameter of grains is normally in the range of 0.5 to 0.8 mm, with some finer recrystallized grains. Rare grains of chert are scattered through the rock. The orthoquartzite in the southwest corner of the map-area is far more strongly recrystallized and contains both muscovite and kyanite, pointing to a higher metamorphic grade.

Lenses of quartz-jasper pebble conglomerate occur here and there in the lower part of the orthoquartzite particularly in the southwest corner. In thin section quartz grains of the conglomerate matrix show varying degrees of roundness – from angular to well rounded. Ilmenite and leucoxene as well as minor hematite are accessories in the matrix. For the most part, the pebbles apparently consist of vein quartz but a few are quartzite, and some are jasper.

Grey, medium-grained gritty quartzite forms a basal part of the unit here and there, but it is not abundant. It is possibly equivalent to Bell's Maguse Member. In this rock subrounded to subangular, poorly sorted grains of quartz, up to 2.5 mm in diameter occur in a sericite matrix, with hematite coating some of the grains, and scattered rare detrital grains of zircon and tourmaline.

Ameto Formation The pelitic unit (AHA) overlying, apparently conformably, the Kinga Formation was named the Ameto Formation by Bell (1970a). As in areas to the east (Eade, 1974; Bell, 1970a, 1970b), rocks of this unit outcrop very poorly and slaty fragments littering the ground are commonly the only evidence for the presence of the formation. The slate, shale, and siltstone are grey to black, or red, fine to very fine grained, and have thin bedding laminations. Prominent slaty cleavage is prevalent throughout the formation. The rock is composed of tiny grains of quartz in a mat of fine biotite and sericite, with minor accessory hematite, leucoxene, and magnetite or ilmenite. Some slightly coarser biotite flakes (0.1 mm or more) are probably of metamorphic origin.

The upper part of the Ameto Formation is intruded by a gabbro sill (AHAg). In this map-area the sill appears to be at or near the top of the Ameto Formation whereas to the east, the gabbro is usually within the shale, slate and siltstone. The massive gabbro has a subophitic texture and consists of amphibole and plagioclase, minor biotite and accessory sphene and magnetite or ilmenite. The biotite apparently results from regional metamorphism.

A small, 15-foot-wide gabbro dyke, trending 190 degrees, cuts the Watterson Formation (AHW) on the northeast side of Watterson Lake. The dyke rock is very similar to the gabbro (AHAg) although some remnants of augite are preserved within the amphibole. This dyke is considered to be an offshoot of the gabbro sills as it is unmetamorphosed in comparison to older dyke rocks (Adb) but is more altered and has a different trend than the younger dyke rocks (Hdb).

Watterson Formation The name 'Watterson Formation' is introduced for the thick carbonate, argillite, shale, siltstone unit (AHW) conformably overlying the Ameto Formation. It includes the lower part of Bell's (1970b) Post-Ameto Complex. In the Kognak River map-area just east of the present map-area it is referred to variously as unit 14 (Eade, 1974), unit 10 (Eade, 1964), or unit 11 (Eade, 1966). In the Nueltin Lake map-area, to the south, equivalent rocks are referred to unit 10 (Eade, 1973). Since outcrops of this unit are sparse and everywhere discontinuous, no good type section exists. In Watterson Lake map-area, despite paucity of outcrops, it has been possible to subdivide the formation into three members (a, b, and c). Member a, a cream weathering, quartz-veined dolomite, containing some stromatolites, with intercalated argillite, shale, or siltstone, is estimated to be 2600 feet thick. Member b, primarily shale, phyllite, and siltstone, with minor interbedded carbonate, is estimated to be 2700 feet thick. The uppermost member, c, consists of well bedded rusty-weathering dolomite containing minor intraformational breccia and some interbedded phyllite, shale and siltstone, and is estimated to be 4100 feet thick. Therefore in the Watterson Lake basin the Watterson Formation is estimated to be approximately 9400 feet thick. Due to the lack of outcrop however, there is little knowledge of smaller folds and possible faults so this estimate is probably too high. In the adjoining Kognak River map-area, a 4000-foot thickness is estimated for this formation.

The lowest member, (a) of the formation is distinguished by the cream weathering dolomite containing lenses and veinlets of white to grey chert that stand above the weathered surface of the dolomite. The layering of the carbonate and of the argillite, phyllite, and siltstone varies from fine (2 cm) to thick (50 m or more). The carbonate layers range from 80 to 95 per cent dolomite, with quartz, minor biotite and/or muscovite and rare plagioclase grains making up the remainder. Biotite occurs in part as coarse metacrysts. In a few places where beds are thin, limestone, rather than dolomite, is present. The fine grained argillaceous beds are composed mostly of quartz and biotite, with minor feldspar, sericite, carbonate and magnetite. Biotite again occurs in part as metacrysts.

The middle member of the Watterson Formation consists of finely laminated grey phyllite, shale, and siltstone with pervasive cleavage and rare interbeds of more massive carbonate. Thin sections of the argillaceous rocks show varying proportions of quartz, feldspar, biotite, chlorite, sericite, carbonate and magnetite. Cleavage and metamorphism have destroyed the original sedimentary texture and pronounced mineral foliation is present with some biotite metacrysts crosscutting the foliation.

The upper member consists of fine to medium bedded, rusty weathering dolomite, and fine bedded shale, phyllite, and siltstone in a ratio of approximately 4:1. The carbonate beds consist of 70 to 85 per cent dolomite with the remainder a mixture of quartz, feldspar and minor biotite, ilmenite and leucoxene. In general the carbonate layers of the upper member are more siliceous than those of the lowest member. An intraformational breccia, approximately ten feet thick, consisting of dolomite clasts in a dolomitic matrix, is present in the lower part of this member. The phyllite, shale, and siltstone beds in the upper member are similar in composition to those in the middle and lower members except that more feldspar is present in the upper member.

Ducker Formation The name 'Ducker Formation' is proposed for the greywacke and siltstone unit overlying the Watterson Formation. It includes the upper part of Bell's (1970b) Post-Ameto Complex. In Kognak River map-area where the unit is best developed, it is referred to as unit 15 (Eade, 1974), unit 11 (Eade, 1964), or unit 12 (Eade, 1966). The name is derived from Ducker Lake in Kognack River map-area for on the north side of the western arm of this lake a section is present that can be considered the type locality. There at least 2000 feet of fine-grained strongly cleaved greywacke to siltstone is present. The unit has a distinct lack of consistency in thickness, for elsewhere in Kognak River map-area it is either absent or less than 100 feet of greywacke and siltstone is present. In Watterson Lake map-area this unit occurs only on some of the islands in Watterson Lake and does not outcrop well. The rock consists of fine quartz grains and minor feldspar in a mat of fine sericite accompanied by minor biotite and accessory leucoxene and ilmenite or magnetite. The quartz grains are poorly sorted and range from silt to finer sand sizes. Cleavage is pronounced and obscures the bedding. Biotite metacrysts are present here and there in these rocks.

Tavani Formation Heywood (1973) introduced this name for quartzose and feldspathic sandstones in the upper part of the Hurwitz Group of the Tavani map-area, equivalent to Hurwitz 'G' of Bell (1970b). Correlation of this unit with unit 16 (Eade, 1974) in the Kognak River map-area is based on lithology as the unit is absent in the region between Tavani and Kognak River map-areas. In Tavani map-area the unit overlies slate and mudstone of the Ameto Formation so the equivalents of both the Watterson and Ducker formations are missing from the sequence. In the type area, the Tavani Formation is composed of pink and brown quartzose and feldspathic sandstones, quartzite, impure quartzite and greywacke. Minor pebble beds and conglomerate lenses are present and locally the rocks are calcareous. In Kognak River map-area, what is believed to be the equivalent formation, unit 16 (Eade, 1974), occurs extensively, and consists of impure quartzite and arkose for the most part, with minor conglomerate and dolomite present in the upper part of the unit. In Watterson Lake map-area, a single heaved outcrop, consisting of angular blocks of arkose, occurs on a small island in Watterson Lake. On the basis of lithology and its stratigraphic position this arkose is considered to be equivalent to unit 16 in the Kognak River map-area (Eade, 1974) and hence to the Tavani Formation.

Undifferentiat

Undifferentiated Hurwitz Group In the southwest corner of the map-area and the small outlier north of Watterson Lake it is not possible to separate the Hurwitz Group units overlying the orthoquartzite. In both areas outcrops are poor and the rocks are more metamorphosed, varying in composition from simple quartz-mica schists to diopside-rich calc-silicate rocks and quartz-bearing amphibolites. They are in the lower part of the almandine-amphibolite facies of metamorphism (Turner and Verhoogen, 1960), probably the staurolite-almandine subfacies, unlike the lower to middle greenschist metamorphism of the Hurwitz Group rocks in the main part of the Watterson Lake basin.

Bate Lake Sediments

A belt of metamorphosed arkose to subgreywacke to siltstone (ABw) and dolomite and phyllite (ABc) occur south of Bate Lake, on the north side of the Krekot Lake quartz monzonite (Agm) pluton. The same rocks are present in another band on the south side of the pluton, north of Watterson Lake. These sedimentary rocks are informally named the 'Bate Lake sediments'. The dolomite and phyllite of the northern band extend northeastward into the adjoining Kognak River map-area (unit 19b, Eade, 1974). The relationship of these sedimentary rocks to the Hurwitz Group, although they occur in proximity to one another north of Watterson Lake, is not clear and is discussed in a later section of this report. The intrusion of the quartz monzonite (Aqm) has removed all evidence as to the character of the basal beds of this unit in this map-area.

The lower formation (ABw) consists of metamorphosed arkose to subgreywacke to siltstone. The rocks are fine to medium grained, light grey to greenish grey, and are well laminated ¼- to ⅜-inch thick beds. The major constituents, present in varying proportions, are quartz (60 to 80 per cent), plagioclase, sericite, biotite, and microcline, with hornblende, epidote, magnetite and garnet occurring in some. Apatite, zircon, sphene, and tourmaline are accessory minerals. Although the intrusion of the younger quartz monzonite pluton has undoubtedly resulted in some contact metamorphism, regional metamorphism has also affected these rocks and it is not possible to separate the results. In spite of the metamorphism, many of the rocks retain distinct sedimentary textures, although in places much modified by recrystallization and development of incipient foliation.

South of Bate Lake a transitional zone of paragneiss and migmatite (ABw'), derived from the arkose to subgreywacke or siltstone, separates the quartz monzonite and the less metamorphosed sedimentary rocks. A similar contact zone is not recognized on the south side of the pluton, perhaps due to the lack of outcrops. Quartz-plagioclase-microcline-biotite paragneiss, commonly garnetiferous, is the typical rock of this transitional zone but it also contains scattered mafic, hornblende-biotite-rich bands, containing up to 60 per cent hornblende.

The upper formation of the Bate Lake sediments (ABc) consists of phyllite with minor intercalated dolomite beds in the lower part, becoming more dolomite-rich upward in the succession. The fine-grained calcareous phyllite consists of quartz, plagioclase, biotite, carbonate, and sericite, in varying proportions. To the south these rocks are more metamorphosed, with recrystallized minerals, foliation, and actinolite and epidote present here and there. The brown-weathering, cream to white dolomite beds, prominent in the upper part of the section on the south side of Bate Lake, are siliceous and typically contain up to 20 per cent quartz. North of Watterson Lake this unit is more highly metamorphosed (ABc') and consists of calc-silicate rocks and mica-rich schist and gneiss. The diopside-rich calc-silicate rocks also contain carbonate, quartz, biotite and feldspar. The phyllites have been converted to quartz, plagioclase, biotite, hornblende, and epidote-bearing schist and gneiss.

Krekot Lake Quartz Monzonite

The Aphebian quartz monzonite is here named after Krekot Lake in the Kognak River map-area where the pluton was first mapped (Eade, 1974). Age determinations on samples of the quartz monzonite are discussed by Wanless and Eade in press. The rock is massive, pink, medium to coarse grained and typically contains 5 per cent or less biotite. Muscovite is present here and there and commonly the biotite is partly altered to chlorite. The potassic feldspar content is variable, most commonly the composition of the rock is quartz monzonite but it ranges to granite in the central part of the pluton and to granodiorite at the margins. Inclusions and schlieren are rare except in the contact zone. Age determinations and tectonic setting of the pluton indicate it is a syntectonic body related to the Hudsonian orogeny.

Some quartz monzonite mapped as Archean (Agdm), to the west of the pluton, could be the younger, Aphebian, quartz monzonite. However, incipient foliation, slightly more mafic composition, and presence of cleavage seems to indicate it is Archean.

Nueltin Lake Granite

The Nueltin Lake granite, named by Wright (1967), is confined to the southeast corner of the map-area, part of a large pluton that extends to the east (Eade, 1974) and the south (Eade, 1973). It is a coarse-grained, porphyritic, pink granite, commonly fluorite-bearing. The granite has been described in detail in a previous report (Eade, 1973). Age determinations on samples of Nueltin Lake granite in southern Keewatin have been discussed in earlier papers (Stockwell, 1972; Wanless and Eade, in press). The age determinations and the tectonic setting of the plutons indicate intrusion of the plutons was post-Hudsonian orogeny, i.e., Halikian.

Mackenzie Diabase Dykes

The name 'Mackenzie dykes' for north- to northwest-trending Helikian diabase or gabbro dykes was first used by Fahrig *et al.* (1965). In Watterson Lake map-area these dykes are not abundant, and do not outcrop well. Where found, the rocks have diabasic texture and are fresh, unlike the old gabbro dykes, (Adb). They are composed of plagioclase and augite, the latter commonly rimmed by hornblende, and abundant accessory magnetite. Due to the magnetite content, the magnetic susceptibility of the dykes is such that their presence can be inferred from the aeromagnetic maps alone.

Structural Geology

In the northern part of the map-area, the dominant trend of layering in the Henik Group rocks and the granitic gneisses is northeast. Dips are normally steep and the few major folds that have been delineated apparently plunge to the northeast. The pattern of folding is dislocated by major north-trending faults in this part of the region.

The arcuate northern belt of Henik Group volcanic rocks reflect the northeast fold-trend as shown by some of the minor folds within the volcanic rocks. To the south of the volcanic belt, the trends of the granitic gneiss, layered gneiss, and paragneiss are northwest for the most part but with variations in the vicinity of the quartz monzonite plutons. As well, some minor folds trend northeast in this region and it is suggested these rocks are complexly folded and refolded.

In the southern part of the map-area, the Hurwitz Group rocks in the Watterson Lake basin form a doubly plunging syncline trending northeast, with minor northwest-trending crossfolds. The axial plane of the main northeast-trending fold dips westward. On the western side of the basin, the lower units of the Hurwitz Group are partly faulted out. In the southwest corner of the area, the Hurwitz Group rocks and layered gneiss generally trend northeast with some local variations near the plutons. This band of Hurwitz Group rocks is cut off on the west and north by faults.

East of Watterson Lake the trend of foliation is northwest, with modification of this trend close to plutons.

The complex structure of the Archean rocks is almost impossible to decipher. The lack of marker horizons, the lack of tops determinations even in the less metamorphosed units, severe dislocations on some of the major faults and the complexity of folding during the Kenoran orogeny, with refolding during the Hudsonian orogeny, all contribute to the difficulty of interpretation. By comparison, the structure of the Aphebian rocks is simple.

Economic Geology

Sulphides (pyrite for the most part) occur in a number of places in the belt of Henik Group sedimentary rocks (As) in the northern part of the map-area. When sheared pyrite-rich beds of the metasedimentary rocks, typically have obvious rusty zones on the weathered surfaces of the outcrop. Thin sections of some of the pyrite-rich rocks suggest they may be tuff rather than greywacke. Assays from two different samples of these pyrite-rich zones show only minor copper (0.01 per cent and 0.03 per cent) is present and in one, a trace of gold.

Sulphide mineralization (pyrite primarily but also pyrrhotite and minor chalcopyrite) is abundant in the northern band of volcanic rocks. The sulphides mostly occur in sheared acid to intermediate volcanics that are probably tuffs, but massive basic volcanics are associated with them. Less commonly, sulphides occur in small shear zones in the basic volcanic rocks. Samples of intermediate tuff containing visible chalcopyrite, which occurred associated with basic volcanics two miles northeast of Boland Lake, were assayed. The results show 0.01 per cent Cu, 0.08 oz./ton of Ag and a trace of gold. A sample of pyrite-rich acid tuff that occurred among basic volcanics six miles southeast of the above sample point, was also assayed but contains only a trace of copper.

In the southern belt of volcanic rocks some disseminated pyrite and pyrrhotite are present in the ultrabasic (Au) rocks but no concentrations were found. However, in the basic volcanic rocks (Am) pyrite and pyrrhotite concentrations, in a few places associated with quartz-magnetite iron-formation, do occur as indicated on the geological map. Assays of samples from some of these contain very small amounts of copper (up to 0.03 per cent), traces of nickel and in a few places, traces of gold.

The small body of amphibolite (Amm), six miles north of Watterson Lake, contains a small zone rich in pyrite, minor chalcopyrite, and with green copper stain on the weathered surface. In the southwest corner of the map-area, near the western boundary, an amphibolite layer in the layered gneiss contains disseminated sulphides.

Although none of the assays of samples of sulphide-bearing rocks indicate the presence of significant amounts of Cu, Ni, Au or Ag, the amount of sulphide mineralization, particularly in the acid to intermediate rocks in the northern volcanic band, is of interest. As well, more detailed inspection of the ultrabasic rocks in the southern volcanic band is warranted.

The possibility of uraniferous conglomerate horizons in the lower part of the Hurwitz Group has created interest in these rocks throughout southern District of Keewatin. A prospecting lease covering areas of these rocks in Watterson Lake basin was held by Eldorado Nuclear Limited and an exploration program was carried out in the 1969 field season. It appears that nothing of economic interest was found. No radioactivity in the limited amount of conglomerate in the map-area was found during the present survey.

Relationship of the Hurwitz Group and Bate Lake Sediments

Nowhere in this map-area, nor in the adjoining Kognak River map-area, are Hurwitz Group rocks in contact with Bate Lake sediments and hence any correlation is based on lithology and stratigraphy. Discussion of the problem in an earlier publication (Eade, 1974), based on data from Kognak River map-area, suggested a possible correlation of the Bate Lake sediments (unit 19, Map 1364A) with the uppermost Hurwitz Formation (unit 16, Map 1364A).

The regional distribution of the Hurwitz Group, Montgomery Lake Group, Ennadai Group and Bate Lake sediments is shown on Figure 1, with the last-named indicated as probable Hurwitz Group equivalent. The suggested lithostratigraphic correlation and nomenclature for these rocks is given in Figure 2.

To the northeast of Bate Lake, in the west half of the Kognak River map-area, the upper part of the Bate Lake sediments is extensively developed with approximately 7700 feet of dolomite and phyllite. There the lower, arkose and quartzite part of the unit is absent, although it is present elsewhere in the Kognak River area below the calcareous-argillaceous unit. In the earlier report (Eade, 1974) it was suggested that the lower quartzite-arkose unit of the Bate Lake sediments was equivalent to the main part of the uppermost Hurwitz Group Formation (what is now called the 'Tavani Formation'), which is composed of impure quartzite to arkose. It is now suggested it is more likely that the lower unit of the Bate Lake sediments is equivalent to only the upper part of the Tavani Formation in the Kognak River area (unit 16b, Map 1364A), consisting of arkose and conglomerate overlying the main part of the Tavani Formation. Some pink siliceous dolomite beds within the arkose are similar to pink siliceous dolomite in the Bate Lake sediments in the Kognak River area (unit 19b). The 'Tavani Formation' in the Kognak River area also includes approximately 100 feet of dolomite and interbedded quartzite (unit 16a) in the upper part, although the relations of these calcareous beds to the main part of the formation are not clear. The calcareous beds may be equivalent to the upper part of the Bate Lake sediments.

If the Bate Lake sediments are equivalent to the upper part of the Tavani Formation, it suggests a major shift to the northwest in the location of the basin of deposition as the Bate Lake sediments overlie Archean rocks. It is noteworthy that the Bate Lake sediments occur adjacent to the Hurwitz Group where the thickest section is preserved. If the proposed correlation is correct, the Bate Lake sediments were deposited in a smaller basin than the Hurwitz Group rocks, the basin lying mostly to the northwest of the larger basin but in part overlapping onto it. In the Kognak River area, major northeast-trending faults commonly bound the Bate Lake sediments and the basins of deposition may have been fault controlled.

A possible correlation of the Bate Lake sediments and the Ennadai Group rocks occurring to the southwest near Kasba Lake should be considered. The Ennadai Group unconformably overlies the Hurwitz Group, having been deposited in a fluviatile environment following faulting and erosion of uplifted blocks of the Hurwitz Group and Archean rocks (Eade, 1971). The depositional basins of the Ennadai Group were small by comparison with that of the Hurwitz Group. The lithology and environment of deposition of the Ennadai Group differs from that of the Bate Lake sediments and they are separated by a minimum of 65 miles. However it is possible that the Ennadai Group and Bate Lake sediments are approximately time correlatives and that their differences are due to different tectonic features affecting the areas of deposition. In the southwest, block faulting resulted in small basins in which continental deposits were laid down but around Bate Lake,

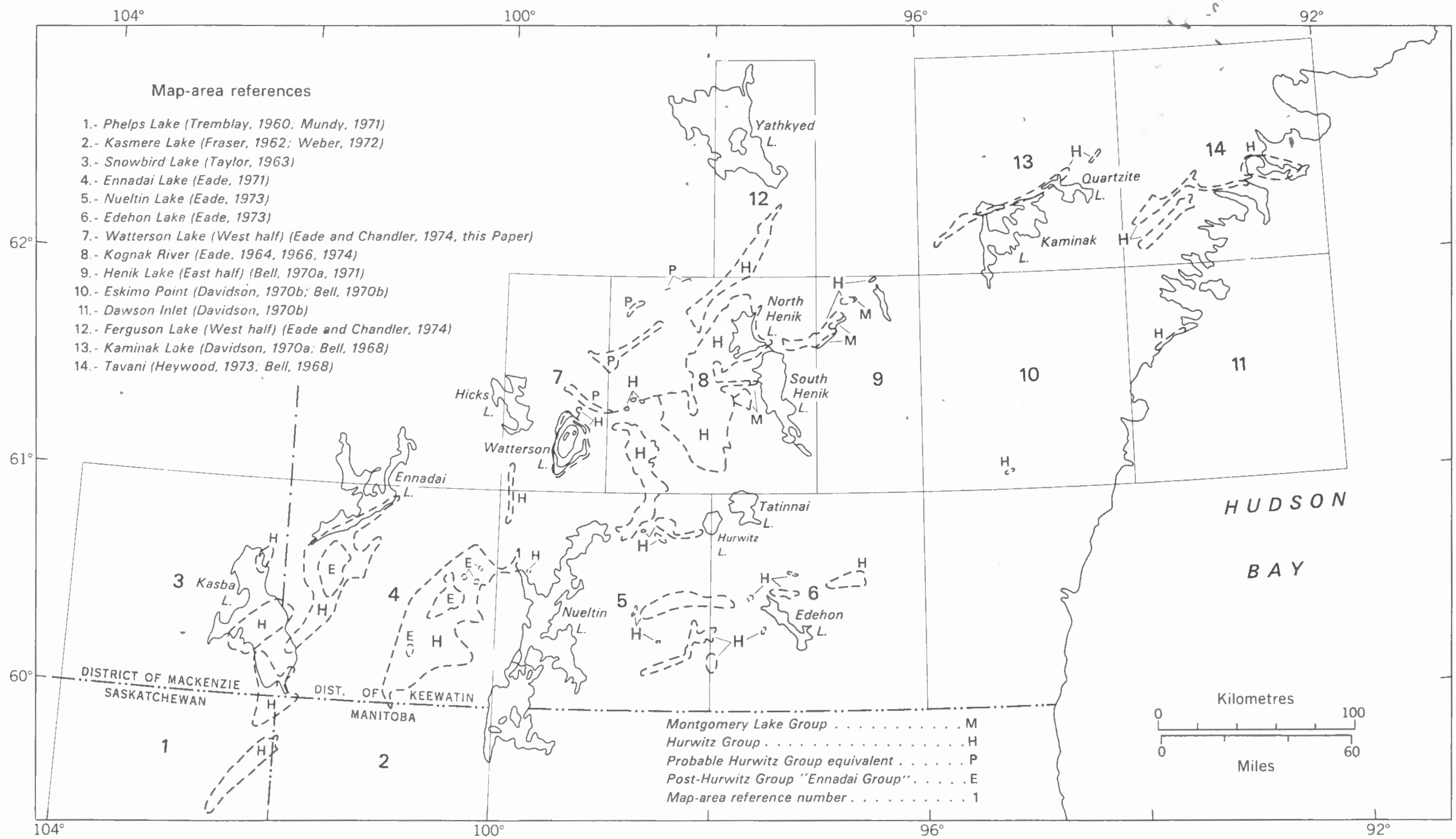

Figure 1: Distribution of Hurwitz Group and associated rocks.

major transverse faults tilted the former Hurwitz basin to the northwest.

In conclusion, it seems most likely the Bate Lake sediments are correlative with the rocks of the uppermost Tavani Formation of the Hurwitz Group in the Kognak River map-area and that they might be time correlatives of the Ennadai Group occurring to the southwest.

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